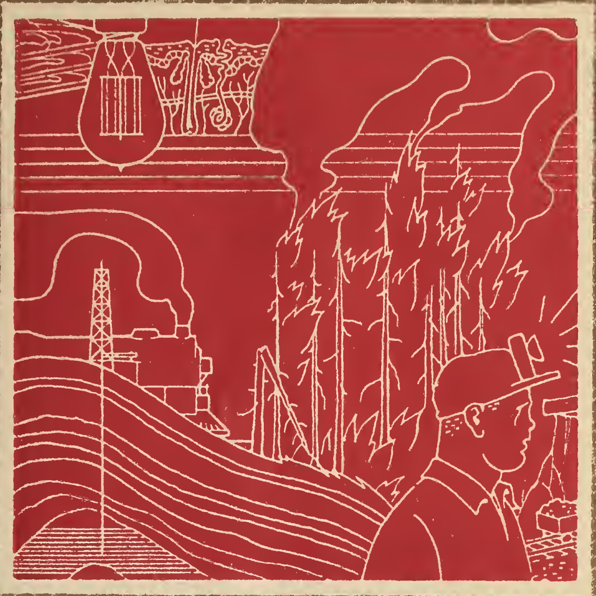

Teacher's Manual for

AND WHY EXPLORATIONS

The
HOW
AND
WHY
ScienceBooks

Frasley G W

A TEACHER'S MANUAL
AND SCIENCE HANDBOOK
to accompany

HOW AND WHY EXPLORATIONS
BOOK VII

of the

HOW AND WHY SCIENCE
SERIES

including also

A KEY TO THE COMPANION BOOK

Prepared by

DONALD G. DECKER

CONTENTS

HOW AND WHY EXPLORATIONS . . .	1
THE DEVELOPMENT OF SKILLS . . .	14
THE SCIENCE ROOM	25
VISUAL EDUCATION	35
TEACHING PROCEDURES	47
BIBLIOGRAPHY	93
A KEY TO THE COMPANION BOOK . .	105

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THE HOW AND WHY SCIENCE BOOKS

WE SEE (PRE-PRIMER)

SUNSHINE AND RAIN (PRIMER)

THROUGH THE YEAR (GRADE 1)

WINTER COMES AND GOES (GRADE 2)

THE SEASONS PASS (GRADE 3)

THE HOW AND WHY CLUB (GRADE 4)

HOW AND WHY EXPERIMENTS (GRADE 5)

HOW AND WHY DISCOVERIES (GRADE 6)

HOW AND WHY EXPLORATIONS (GRADE 7)

HOW AND WHY CONCLUSIONS (GRADE 8)

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HOW AND WHY EXPLORATIONS

A WORD TO THE TEACHER ABOUT THE TEACHER'S MANUAL

The good science teacher uses a variety of methods to teach his subject. He knows that many different learning activities are educationally sound. He also knows that there should be time provided for students to work individually so that he may give his attention to the study habits and the individual problems that students may have while they are working by themselves. The suggestions made in the teachers' manuals attempt to show many different ways to present information through a variety of activities so that individuals may apply their information in a number of different ways.

Suggestions are made to help the teacher develop with the students a method for constructing a study guide. When students are able to do this by themselves they will have acquired certain study habits and skills which will be of benefit to them later. It is suggested that a number of units be used in this way so that students accumulate the skills required to organize and follow through a study guide by themselves. There are also suggestions by which a teacher can develop certain scientific facts by a discussion of the diagrams and pictures in the units. If the school equipment is very meager the illustrations in the textbook and Companion Book may be used to great advantage. Some children who have difficulty with reading will appreciate the attention that is given to learning from diagrams and pictures. It is often well for the teacher and the students to work together in setting up problems and figuring out the information that should be used to solve them. Overview lessons may be presented by the teacher to discover the questions that students wish to have answered. The introductions to some of the units suggest that this method be used.

How well students understand science material may often be

discovered by work upon a program to be presented for the parents or material to be dramatized to illustrate to someone else what has been learned. The information presented in these programs must be accurate, and if students can repeat and apply accurate information in these kinds of situations they probably know the material very well.

Some suggestions are made for selecting facts from information to explain the pictures or to answer the topics and the problems in the unit. In using this manual, the teacher should think of it as a source of suggestions for the teaching of the material in the textbook and the Companion Book. If some of the methods are better suited to his purpose, those methods should be used and the pattern followed for other units suggested by the manual. If a teacher wishes to help students develop study guides and use this method for the study of each of the units, he should follow the same pattern suggested for the teaching of the first unit.

The suggested activities following the suggestions to the teacher are activities which pupils may enjoy in addition to the ones suggested in the textbook and the Companion Book. All of these methods, suggestions, and aids, are for the purpose of helping the teacher make meaningful the scientific facts of each unit. These scientific facts are listed for each one of the units. The manual is not intended to be a day-by-day direction to the teacher. After the teacher has read the textbook, the material in the Companion Book, and the material in the teacher's manual for any one unit, he should organize his own teaching procedures with these ideas in mind as suggestions. No printed material can do what the teacher can do for himself. Improvement must first take place in the mind of the teacher.

THE ORGANIZATION OF HOW AND WHY EXPLORATIONS

Two main objectives have been accomplished by the selection and organization of the units for How and Why Explorations.

1. A presentation of the basic science subject matter important for children to experience while they are in school.

2. Examples of the application man has made of this subject matter to the solution of his problems and the improvement of his living.

The first part of each unit in How and Why Explorations is organized to present the scientific information by experiences or examples which make it meaningful to the reader. The rest of each unit is devoted to describing applications man has made of this scientific information.

One of the objectives of educating public school children in the field of science is to make it possible for them to analyze, explain, or predict the events with which they come in contact, both in and out of school. Science education should serve a future purpose as well as an immediate one. Therefore, the applications which are explained should be those that are within areas that are constantly important to the welfare of man. There are many areas in science which are not of as great importance to the general public as are other areas. The topics listed in the table of contents show the major areas with which the children will deal. The individual and his skin, food, health, and teeth are examples of areas of constant importance throughout life. The effect of light, the atmosphere, and rocks are parts of the environment which continually change the things that we do as individuals throughout our life span. As long as man lives he will be concerned with transportation, temperature control, and electricity. Conservation, the reproduction of plants, and the exploration of new and different parts of the world will present problems as long as man lives and works in a scientific age. There may be other areas of equal importance but one of the keynotes of the material presented in this book is that each of these units has been of continuing importance to classes of seventh-grade pupils. Classification of student questions constantly re-affirm the importance of these areas. The work of students in the elementary school, from kindergarten through the sixth grade, have been largely within these major areas. How and Why Explorations provides an opportunity to build upon these experiences or to develop them for the first time if students have not been fortunate enough to attend schools in which there were elementary science programs. This organization of material makes

it possible to attain certain objectives that cannot otherwise be accomplished in a science program.

THE OBJECTIVES OF SCIENCE EDUCATION

Science teachers should always ask themselves: "For what purpose am I including this science subject matter as a part of the experiences of my students?" A good science teacher does not confine himself to teaching the material in the textbook. He provides experiences by which students can obtain objectives which they could not achieve if they dealt only with the textbook. For this reason the Companion Book should be used with How and Why Explorations. Although the textbook and the Companion Book have been written to give the utmost assistance to the teacher by providing experiences which will accomplish certain otherwise unobtainable objectives, the skill of the teacher must still be used to make these meaningful to students. It is essential that the teacher have in his own mind the major outcomes for which he is educating his students. A student should have gained more than mere information as a result of his experiences in science. He should be able to use this information in a number of different ways. These are suggested below:

1. He uses the facts and principles of science which he has learned as tools with which to analyze the cause of events.
2. He uses the facts and principles of science as tools with which to predict the cause of events.
3. He uses the facts and principles of science with which to explain the cause of events.
4. He uses the facts and principles of science which he has learned as tools with which to analyze the result of events.
5. He uses the facts and principles of science as tools with which to predict the result of events.
6. He uses the facts and principles of science with which to explain the result of events.

A reference to the units included in How and Why Explorations will help make these objectives more meaningful. As a result of his experiences with the textbook and the Companion Book, a student should be able to analyze the basic causes of fingerprints,

blood types, the effects of light, atomic energy, changes which occur in his skin, forest fires, growth of trees, behavior in relation to food in the body, weather changes, functioning of an electric motor, plant reproduction, growth of teeth, the functioning of railroad engines, water in the community, and the kinds of rocks within a community. Of all the information which he gathers he should have developed the skill to select from that information the causes of certain things. This selection is dependent upon his skill to analyze in relation to the concept of cause. With this knowledge of cause he should be able to predict the results, and he should be able to analyze his information to discover the relationships which exist between the cause and the result. Each unit in the book emphasizes certain causes in relation to certain areas of science. Results of these are explained in the application of this information to problems which scientists are trying to solve.

If a student as a result of his science program does not know as much as those who have not had the benefits of the program, his education has been neglected. Students today have acquired a great reservoir of common knowledge from newspapers, magazines, the radio, movies, and travel. The units in How and Why Explorations consist of information about which most people talk.

Teachers should feel a special responsibility to convince students that there has been a worthwhile effect on the welfare of man by solving problems with scientifically determined evidence.

Students should also be informed of the progress that man has made and the changes which have occurred as he has lived and applied scientific knowledge to the solution of his problems. The teacher who believes these objectives to be important will also be concerned in pointing out the relationships which exist between scientific knowledge and the social behavior of man. He will be sure to emphasize evidence which shows that the application of scientific knowledge has changed social institutions. Provisions must be made for students either to have their questions answered or to understand why the questions cannot be answered when they are asked. Students who have had a science program should desire to do those things that characterize a healthy and emotionally mature individual. They should also know other sources of scientific information so that they can continue to find answers to their questions when they are no longer in school. Basic to all of these

objectives is the emphasis which is given to the development of certain skills that are essential if a student is to continue his own learning.

It is true that these objectives emphasize social action and the results of man's application of scientific knowledge. In an age in which scientific information daily changes the lives of people, it is important that students first think of these social implications. If they should specialize in the field of science they will have developed a social consciousness in relation to the work which they are to do. Even though the student does not desire to make a career of science, his thinking and his attitudes toward the activities in which he does engage should be colored with science facts and a conviction that opinions, superstitions, prejudices, and unfounded beliefs are poor substitutes for the solutions of problems. American schools are designed to educate an American public whose members are going into many and varied life activities. Common goals, common interests, and objectives which are worthwhile to all are requisites of a science program in public education. Through such a program great emphasis can be given to the need for new scientists who will devote their energies, as scientists are now doing, to the improvement of the nation in which they live.

A SUGGESTED TIME SCHEDULE FOR TEACHING HOW AND WHY EXPLORATIONS AND ITS ACCOMPANYING COMPANION BOOK

Many teachers are interested in the amount of time that should be spent upon each unit. It is difficult to suggest a schedule which would be applicable to each school organization. The one presented in the chart below is constructed for a nine-months' course in which science is taught one hour a day each day of the week. Teachers should vary the time schedule to fit their own particular schools and classes. Some teachers plan to cover the entire book and other teachers plan to cover only a portion of it. The time schedule would have to be revised accordingly. It is important, however, that a teacher teach the units in the order in which they are written unless he has carefully organized the material to be sure that he is not asking students to study something for which they do not have the background.

Unit	Pages In Textbook	Pages In Companion Book	No. of Weeks (1 hr. per day)
1. Scientific Identification	5–14	1–9	1½
2. Light	15–38	9–25	2
3. Atoms for Energy	39–45	26–30	½
4. Metric System	46–47	31–36	½
5. Your Skin	48–81	37–48	2½
6. Summer in the Forest	82–107	49–66	2½
7. You and Your Food	108–162	66–87	3½
8. Weather and Flight	163–208	88–105	3
9. Electricity	209–230	105–114	2½
10. Hospitals and Health	231–242	115–120	1
11. Plant Reproduction	243–253	121–123	1
12. Fire for Man	254–282	124–128	2
13. Temperature Control in the Home	283–304	129–134	1
14. Your Teeth	305–321	135–139	1
15. Engines on Tracks	322–343	140–146	3
16. Water on the Land	344–370	147–149	2
17. Scientists Explain Rocks	371–386	150–155	1½
18. The Club Explores An Ancient City	387–404	156–158	1

MULTIPLE USES OF THE TEXTBOOK AND THE COMPANION BOOK

The charts which follow show the organization of the material in the textbook and the Companion Book according to a number of classifications.

Chart #1: (See pages 10 and 11)

1. The list of topics which compose How and Why Explorations.
2. The pages on which scientific facts are taught in relation to each one of these topics.
3. The pages on which application in the textbook is made to the individual, the home, or the community.

4. The pages in the Companion Book of the exercises to use to teach scientific facts in relation to these topics, in addition to the facts taught in the textbook.
5. The page numbers of exercises in the Companion Book in which the student must make application to the individual, the home, or the community.
6. In addition the chart also shows topics which are devoted to four major areas of importance in science education: conservation, health, transportation, and safety.

All of the material in the textbook and the Companion Book is so organized that a number of objectives of science education are accomplished at once. Unified learning is possible. The major areas of social concern are emphasized throughout both books. In addition to this unification of scientific fact and application, the Companion Book has been organized to develop certain skills. They are as follows:

Chart #2: (See pages 12 and 13)

1. Problem Solving
   - *a.* The steps of problem solving
   - *b.* The recognition of problems
   - *c.* Stating problems
   - *d.* Gathering and recording information
     - (1) In charts
     - (2) In diagrams
     - (3) In drawings
     - (4) In experiments
     - (5) In graphs
     - (6) In maps
     - (7) In pictures
     - (8) In tables
   - *e.* Analysis
   - *f.* Synthesis
2. Reading Skills
   - *a.* Using an index
   - *b.* Reading for specific information
   - *c.* Reading to select main ideas in a paragraph
   - *d.* Using reading signals

The charts indicate how many times throughout the year a student will be working with the various skills and the various areas

of subject matter and their application. If a teacher wishes to evaluate students on their ability to record information, a reference to Chart #2 indicates the eight exercises that could be used as a basis for this evaluation. If a teacher wishes to devise a marking scheme and to use a chart similar to the one printed, it would be possible at the end of the year to indicate the amount of growth that had occurred by reference to how well the student had done the exercises for any one skill. If a teacher wishes to review the area of health, Chart #1 indicates the pages and the units that should be reviewed in order to determine a student's comprehension of the important knowledge and attitudes in relation to this topic. If a teacher should wish to reorganize the material in the book, it would be possible to concentrate upon those problems which are of concern to individuals first. Since these have not been confined to one section of the book, the basic information needed for each unit will have been developed previously. The same organization could be followed for the home or the community. If a teacher or a school is attempting to unify social studies with science, as many schools are doing, Chart #1 presents the organization of the material in such a way that it is apparent which units can be used for various topics that are to be correlated with the social studies program. Other schools unify English and science. The development of the skills in reading are presented in Chart #2. When a student has finished the exercises in the Companion Book, he should be able to use his writing skills in making lists to classify things, construct sentences which state reasons, answer questions, describe, record facts, make lists of the order of a procedure, and construct sentences which explain why, how, or what happened. Little effort is required on the part of the teacher to do other than to emphasize the many things the student is learning at once. The facts he learns in science become useful tools to him in relation to four major areas, to four areas of social application, and to a variety of skills involved in problem solving and the recording of information in many forms. Reference to the charts will help the teacher introduce each unit and series of exercises in the Companion Book so that students will know the variety of things they will be doing as they study the textbook and do the exercises in the Companion Book.

CHART 1—HOW AND WHY EXPLORATIONS TEXTBOOK AND COMPANION BOOK

Units in How and Why Explorations and Its Accompanying Companion Book	Sci. Fact		Application of Scientific Fact												
	T *	C †	T	C	T	C	T	C	T	C	T	C	T	C	C
	Scientific Fact	Scientific Fact	Individual	Individual	Home	Home	Community	Community	Conservation	Conservation	Health	Health	Transportation	Transportation	Safety
1. Scientific Identification		7	8, 9, 11	2, 3, 6				1, 4							
a. Skin	9														
b. Blood	12														
2. Light	15–25	12–17 20–25	25		36–38	18, 19		14, 16							11
3. Atoms for Energy	39–43	26–30													
4. Metric System	46	31, 32, 35, 36		33, 34											
5. Your Skin	48–68		48–81	39–43 45							48–81	37–45			46 48
6. Summer in the Forest		56						51, 57	82–107	52–61					
a. Tree Growth	98–103														
7. You and Your Food			108–162	69, 70, 77, 80				85			108–162	69–85			
a. Food	116–128			81, 83 88, 94											
b. Digestive System	133–162														
8. Weather and Flight		95				101		93, 95 98–100					163–208	103–104	101

* T = textbook
† C = Companion Book

CHART 1—HOW AND WHY EXPLORATIONS TEXTBOOK AND COMPANION BOOK *(continued)*

Units in How and Why Explorations and Its Accompanying Companion Book	Sci. Fact		Application of Scientific Fact												
	T *	C †	T	C	T	C	T	C	T	C	T	C	T	C	C
	Scientific Fact	Scientific Fact	Individual	Individual	Home	Home	Community	Community	Conservation	Conservation	Health	Health	Transportation	Transportation	Safety
a. Atmosphere	103–171														
b. Weather	172–208														
9. Electricity	209–218	107–109			219	110	220–230	111, 112, 113							
10. Hospitals and Health				116			231–243	117, 118			231–242	115–119			
11. Plant Reproduction	243–251	123							243–253	123					
12. Fire for Man		126			267–282	124–128					254–282	124–127			
a. Fuels—Combustion	254–256														
13. Temperature Control					283–304	131					283–304	129–134			
14. Your Teeth	305–309		305–312	135–139			313, 321				305–321	135–139			
15. Engines on Tracks		140–141											322–343	140–146	
a. Internal Combustion	335–342														
16. Water on the Land	344–370						346–370	147–149	344–370	149					
17. Scientists Explain Rocks	371–386							151–155	371–386	151–152					
18. Ancient City	387–404						387–404	157–158							

CHART 2—HOW AND WHY EXPLORATIONS COMPANION BOOK

Units in How and Why Explorations	Problem Solving													Reading Skills			
				Gathering and Recording Information													
	Steps of Problem Solving	Recognizing Problems	Stating Problems	Charts	Diagrams	Drawings	Experiments	Graphs	Maps	Pictures	Tables	Analyzing	Synthesizing	Use of Index	Selecting Specific Information	Selecting Main Ideas in a Paragraph	Using Reading Signals
1. Scientific Identification		5				2, 3	2, 3					8					
a. Skin																	
b. Blood																	
2. Light		9, 10		14		20, 21	19, 21, 22							25			
3. Atoms for Energy																	
4. Metric System							32	34									
5. Your Skin		37	46	45		33	33, 44, 45					38	40, 41, 42				
6. Summer in the Forest	62–65					58, 59, 61			49–51			60			53, 54		
a. Tree Growth							57, 53, 59, 60										
7. You and Your Food	78–79				77		71				73					66	74–75
a. Food							76, 73										
b. Digestive System							81, 84										
8. Weather and Flight	105–106			98, 104		84, 85, 95		93				81, 82, 95			99–100		
a. Atmosphere																	
b. Weather																	

CHART 2—HOW AND WHY EXPLORATIONS COMPANION BOOK (*continued*)

	Problem Solving													Reading Skills			
				Gathering and Recording Information													
Units in How and Why Explorations	Steps of Problem Solving	Recognizing Problems	Stating Problems	Charts	Diagrams	Drawings	Experiments	Graphs	Maps	Pictures	Tables	Analyzing	Synthesizing	Use of Index	Selecting Specific Information	Selecting Main Ideas in a Paragraph	Using Reading Signals
9. Electricity				110				111, 112, 113				107, 114	109				
10. Hospitals and Health										120, 122							
11. Plant Reproduction																	
12. Fire for Man					126, 127, 128												
a. Fuels—Combustion							124, 125										
13. Temperature Control							129, 130, 133			134							
14. Your Teeth				136			137								137–139		
15. Engines on Tracks				140		146	146					142–145					
a. Internal Combustion																	
16. Water on the Land					147, 148												
17. Scientists Explain Rocks									149								
18. Ancient City										156, 157							

THE DEVELOPMENT OF SKILLS

PROBLEM SOLVING

The elements of problem solving should always grow out of experience. They are more meaningful if they are the result of experience rather than the experience itself. If children are taught lessons in which they learn the steps of problem solving and are expected to know these steps at the conclusion of the lesson, problem solving will never be as meaningful to them as when they engage in experiences in which they discover for themselves the value of the scientific method and the usefulness of the steps in problem solving. In addition to recognizing the steps of problem solving, it is important for students to be able to explain why problem solving is valuable and useful. The student who has come to the conclusion, through experience, that problem solving is valuable can use the method to direct, change, and transform future experiences.

The teaching of problem solving has probably been more consistently "butchered" by science teachers than the teaching of any other area in the field of science. Most teachers recognize the benefits of teaching problem solving but they fail in their endeavors to accomplish what they set out to do. There are several reasons why this is true. Often teachers believe that all the skills involved in problem solving must be taught at the same time and that each student will be equally proficient in these skills. Other teachers leave the teaching of problem solving to be absorbed by the students without direct effort to help them learn to be skillful in the use of this method. Students who have not developed skills in problem solving need to have the method taught to them as carefully as one teaches the subject matter in the textbook. The great objective of problem solving is to make students intellectually independent of others in the acquisition of information. Students remain intellectually immature as long as they are dependent upon others to direct their learning activities. The exercises in the Companion Book are designed to help in the gradual development

of these skills. If a teacher concentrates upon the development of one skill at a time, he will probably be more successful in teaching problem solving to his students. No teacher will succeed in teaching problem solving if he himself has not acquired the skills. The teacher also needs to recognize the various parts of problem solving in relation to each other.

Recognition of Problems

The first essential in problem solving is the recognition of a worthwhile problem. Students can be taught to recognize worthwhile problems if definite standards are developed which can be used to judge problems that are being evaluated.

1. A good problem contains only one main idea. Questions which contain two main ideas divide the attention of the learner and make it necessary for him to solve two problems at the same time which is somewhat difficult for him to do. There are a number of different ways to help children recognize the main idea of a problem. One is to list a number of problems which children suggest and then to ask the students to underline the main idea. For example: "How can light be used to take pictures?" The main idea in this problem is light. The rest of the problem concerns itself with a special application of light. Another exercise in using this standard to evaluate problems would be to list the problems and questions in How and Why Explorations and then to underline the main idea in each of these problems. Another kind of exercise would be to list the topics in How and Why Explorations and to ask the students to change these topics into problems and then underline the main ideas. These could be done at the beginning of the year as a survey of the contents of the book that the students are to study and to provide the teacher with information as to how well students can judge a problem by this one criterion.
2. A good problem usually begins with *how* or *why*. Problems which begin with these words demand a recognition of relationships in the evidence which is gathered to solve the problem. A conclusion which answers the question of how or

why demands a statement of relationships. Questions which can be answered with a list of things, a definition, or yes and no, are not the best kinds of problems because they do not demand so high a degree of learning.

3. A good problem is stated in question form. It should begin with a capital letter and end with a question mark.

4. A good problem emphasizes a social application of scientific information if possible. It is of importance to students. It is challenging to them. It can be answered. If students can recognize and state problems which conform to these standards, they have developed one skill essential to problem solving.

The statement of a good problem is not the end of education in problem solving, but identifying in that problem the purpose or the reason or the application is one of the significant objectives. "How can I make the problem most worthwhile to study?" should be the major concern of those who work on problems. When a problem has been stated well, it is comparatively easy to outline the things that need to be done in order to solve the problem. Usually the first activity is to list the sub-problems which must be answered before the main problem can be solved. An example from page 38 of the textbook can be used to explain this. "Can light be produced without heat?" is not a good problem because it can be answered with yes or no. To change this to meet the standards it would have to be stated this way: "How can light be produced without heat?" In order to solve this problem a person would have to know the answers to the following questions: "What is light?" "What is heat?" "What is the relationship between light and heat?" "How is light produced?"

Making a Study Guide

When the sub-problems have been stated and it is recognized that these may be either simple questions or problems, a student is ready to decide the activities which will help to provide information to answer these questions and problems. The student may plan to read, to observe, to experiment, or to listen in order to gather his information. The amount and kind of reading that he

does will depend upon materials available. Those things which he observes will be dependent upon the equipment in the school and the kind of community in which he lives. This will be true also of the experiments that he can do. Listening includes activities such as interviews, guest speakers, discussions, and committee work. These again are governed by the people available in the community, the school, and the amount of time that can be devoted to such activities. It is wise for the student to get into the habit of planning carefully and realistically the things he can do.

Gathering Information

The student should make a survey of the available materials, equipment, and people from which he may gather information about his problem. Several suggested activities in the teacher's manual will help teachers plan with students for the activities that it is possible for them to do to solve problems. Even though the activities are confined to the use of How and Why Explorations and the accompanying Companion Book, and the simple material suggested for the demonstrations and experiments, the student can learn the basic skills of problem solving which will not change when more materials and greater opportunity is provided for gathering information from a wide variety of sources. A teacher does not need to feel hampered because the equipment is meager or the time not available for many different kinds of activities. The teacher should remember that the student is going to study by some method. It is no more time-consuming to study by the problem solving method than by any other. If movies, field trips, interviews, and library work are included, the method is not more time-consuming, but the activities which are used consume time. The basic essentials can be learned in the same amount of time that it would take to use any other method for study. At the beginning of problem solving the wise teacher does not permit the student to gather so much material that it is not possible for him to organize it. Teachers often make the error of urging a student to acquire a great mass of material which would take six months to organize. This is why it is so important that a teacher approve study outlines before students begin to work upon them. A few well chosen activities can result in more worthwhile information

than a great list of exciting and varied activities may do. Students always want to do more things than they can possibly do in the time allowed. If teachers permit this to happen, both teacher and students finally come to the conclusion that there is not time to do it all, that the students have wasted their efforts, and that problem solving is a poor way to teach. Teachers should blame themselves for the inadequate directions which they have given students rather than blaming the method, which is at the mercy of the teacher. Activities should always be planned in relation to the amount of time available for the solution of the problem. Any one of the units in How and Why Explorations might consume a whole year if children are allowed to perform every activity which they suggest in connection with each unit. It is also the responsibility of the teacher to evaluate the suggestions that students make and to make suggestions to the students of worthwhile activities. Teacher-pupil planning in problem solving should not result in a teacher's losing his function in the classroom. His effect upon the students should be more worthwhile. He should always be looked upon as the person whose experience and training make him capable of evaluating and determining the activities that should be performed.

Analyzing Information

When the information has been gathered it may be in the form of notes, charts, diagrams, maps, or pictures. As soon as the gathering of information is completed, the student should sit down with this information and write on a piece of paper the question or problem he wishes to answer. He should underline the key ideas in this problem. With these in mind he should review the information he has collected. Under the problem he should write in sentence form the information from his material which will help to answer the problem. When the student is listing his information in sentence form under each one of the problems, he is performing the activity called "Analysis of Information." It simply means that he is selecting from his information those ideas which are related to the main ideas in the problem he is solving. Seventh-grade students are able to understand this explanation of analysis. As they become more skillful in the use of the problem

solving method they will be more critical of the information they gather. The teacher or the students should not be discouraged if useless information has been included. The only person who can learn to use the problem solving method is the learner. He will never achieve proficiency if all the thinking occurs in the mind of the teacher. A teacher must be content to allow students to learn by the experiences which they themselves have. Education is more meaningful to those students who are allowed to make conclusions themselves on the basis of their experiences than is education where all the conclusions are made by the teacher. The thrill and the excitement of feeling the satisfaction of improvement cannot come if the teacher is the only one who improves. It is the responsibility of the teacher to urge students to evaluate their experiences so that they will consistently gather better information and make wiser selections as they gather it.

Synthesizing Information

The next step in problem solving has always been difficult for teacher and student to understand. This is usually true because the purpose has not been clear to either one. After the evidence has been listed in sentence form under each question or problem, a student may discover he has a list of twenty ideas, each one related to the problem. What is the next logical step to perform in getting an answer to this problem? The student needs to summarize this information into a conclusion which will answer the problem. Certain skills will help a student do this. For example: He may underline each word in the sentence which is related to a main idea in the problem. The next step is to group these words which he has underlined so that those that are related are grouped together. There are two things that the student does unconsciously when he is constructing these groups: (1) in order to put words together in one group he needs to recognize similarities among ideas; (2) in order to place words in different groups he must recognize differences among the ideas. The basis of this step of problem solving is concerned with the recognition of similarities and differences. The third part is a more difficult function of the learning processes—it is learning to recognize relationships among these groups of ideas. These relationships are identified by

the main ideas in the problem. The student should always ask himself, "What is the relationship I am trying to explain? How are these ideas connected? Why does one idea help explain another?" When he has decided what this relationship is he is ready to state the conclusion to his problem. This process is called synthesis. Synthesis means that a person has identified and grouped the main ideas together. If a teacher directs students through the process of synthesis according to the suggestions above and then says to them, "What is it that we have done?" students are able to list the steps which have been performed. If the teacher then says that these steps represent the process called "synthesis," the student identifies in his mind this word with activities he has already performed.

Making a Conclusion

When the conclusions have been stated for each one of the subproblems, it is again necessary to synthesize in order to make a statement which will be a conclusion to the main problem. The same procedure can be used again. When the student has his conclusion to the main problem, it is well to verify it by reviewing his evidence, doing additional reading, asking an authority, doing other experiments, or by comparing his conclusion with others made by students in the class. Many science teachers believe that the end of problem solving should be application of the conclusion to social situations in which it can be used to explain, predict, or analyze. The application of the information with which the student deals should be a part of each experience he has with his problem so that the significance of it is a constantly growing and expanding concept. Too often the information is gathered and the application of it inconsequential and hurried. A good summarizing activity in which conclusions can be used in the framework of application is to suggest many different situations to see if the student can recognize the similarity between the situation and the conclusion he has made. This is also an excellent way in which to evaluate the meaning the student has developed in relation to the conclusion he has made. Other teachers believe that a hypothesis should be included as a part of this procedure. In a question such as, "How can light be produced without heat?" it

may be impossible for a student to make a hypothesis if he is entirely ignorant of the basic facts connected with the problem and if he has had no previous experience upon which to make a hypothesis. Forming an hypothesis and verifying are two steps in problem solving which often seem inconsequential to students because one has to "stretch his imagination" in order to perform either one of these steps. The essential scientific attitudes can be developed without the inclusion of these two steps at the junior high school level. If the problem is one about which a person can make a sensible hypothesis and one in which verification is possible, then these two steps should be included. The teacher should always emphasize the fact that any conclusion to a problem is not recognized as the final one—that it is important only as it reflects the evidence which has been gathered. If more evidence is gathered and more time is devoted to it, the conclusion may change. For this reason most conclusions made by students in the seventh grade are in the nature of hypotheses. As students grow and develop in their proficiency they can perform more and more of these steps by themselves. A good foundation in problem solving in junior high school should make it possible for a student to direct efficiently a great deal of his own study in senior high school.

READING SKILLS

Most of the activities students perform in junior high school in relation to science are reading activities. If science is to be learned, reading skills must not be neglected. It is often true in the junior high school that the reading skills so carefully developed in the elementary school are either neglected or forgotten entirely. As reading materials change and increase in complexity, the skills the student has learned in elementary school should be re-applied to each new kind of material. Only through their application do students continue to be proficient in the use of them. Several reading skills most essential to the selection of important information from reading material are emphasized in the Companion Book. There are exercises which suggest to teachers ways of helping students do the following:

1. To identify the meaning of new words.
2. To recognize reading signals which indicate how many, results, definitions, and causes.
3. To select specific ideas to answer questions.
4. To recognize the main ideas in a paragraph.

Each one of the exercises which has been made to further these skills in reading can be used as suggestions for the teacher to develop other exercises which can be made for other sections of the book. At the beginning of the year's work the teacher should identify the exercises in the Companion Book which are designed for this purpose (see Chart #2, pages 12 and 13) and make more of his own if he feels this is an important thing to do. Space in the Companion Book does not permit the inclusion of the number of exercises actually necessary to constantly and consistently develop these skills.

THE RECORDING OF INFORMATION

It is easier to judge the understanding which children have of information if they can record the same information accurately in a number of different ways. A student who can record his information in writing, in a bar graph, a circle graph, a line graph, a picture, a diagram, and a map probably understands and can use his information as a tool. For this reason many of the exercises in the Companion Book demand that students record their information in a variety of different ways. Certain exercises are devoted to the teaching of the skills essential for this. Other exercises help students to select information from a variety of different sources (see Chart #2, pages 12 and 13).

EVALUATION

Teachers who concentrate upon the improvement which students make can usually demand a higher type of achievement of their students than teachers who do not emphasize improvement as a major objective of the year's work. If students are evaluated upon the amount of improvement they make individually rather

than in competition with other students, there is more incentive to improve. A student may feel that it is possible for him to improve but he may also know that it is impossible for him to improve to the same degree that another student in the class does. Therefore, individuals should be evaluated by the actual improvement that takes place. It is still necessary in some schools to evaluate students in relation to each other. Therefore, two types of evaluation should be made by the teacher. The former is more meaningful to the students, the latter may be an administrative necessity. Most students like to know how well they do in relation to themselves and also in relation to other students in the class. The following criteria for evaluating students in the science class is suggested:

1. The student knows the scientific information in relation to each topic in the textbook and the Companion Book.
2. He can use scientific information to explain what happens in the human body.
3. He can use scientific information to predict what will happen in the human body.
4. He can use scientific information to explain events in his home.
5. He can use scientific information to explain events which occur in his community.
6. He uses the steps of problem solving.
7. He recognizes problems.
8. He states problems.
9. He analyzes information.
10. He synthesizes information.
11. He uses an index correctly.
12. He can obtain information from maps.
13. He can read for specific information.
14. He can select the main ideas in a paragraph.
15. He can select information from a table.
16. He uses reading signals.
17. He records information accurately in diagram form.
18. He records information accurately by drawing.
19. He records information accurately in graph form.

20. He records information accurately on maps.
21. He uses safety skills.
22. He uses experiments as a source of information.

A teacher may use the following symbols to record how well the student has achieved the above objectives: An "O" may be used to indicate outstanding achievement, an "S" for satisfactory achievement, an "N" if the student needs to improve, and a "U" if the student is unsatisfactory. If at the end of the year a student has received "S" consistently in any one of the above objectives he will be rated as satisfactory. Students should know and perhaps keep their own records so that they can judge the progress they are making in the development of these skills for the learning of science subject matter and its application.

THE SCIENCE ROOM

PLANNING THE SCIENCE ROOM *

Ideally a science room should be planned as a place where students may carry on all the science activities that contribute to the objectives of science instruction. This means that a science room should be equipped for general classroom activities, demonstration work, and laboratory work. Such a room will make it possible for teachers and pupils to change quickly from one type of activity to another and thereby provide better co-ordination between all science activities. Such a plan will also eliminate the economic losses that are encountered when science laboratories are separated from the science classrooms.

Size of Science Rooms

There is at present no scientifically standardized size for a science room. Science rooms will obviously differ considerably in size, depending upon the number of pupils to be accommodated. For an efficient science program, in justice to both pupils and teacher, the laboratory class should not exceed twenty pupils. Where classroom work other than individual laboratory work by pupils is conducted, a room sufficiently large to accommodate thirty pupils may be used.

It is highly desirable, when a new school building is to be built, that the science staff, the school administrators, and the architect work together in planning the details of the science rooms.

Laboratory Furniture

A large, instructor's demonstration table (8 to 12 feet in length) should be centered in the front of the science room. This should be equipped with running water, a sink, and gas and electrical out-

* The sections entitled "Planning the Science Room," "The Planning and Purchase of Equipment," and "Homemade Equipment" on pages 25–34 are quoted directly from the *Forty-Sixth Yearbook, Part I, Science Education in American Schools*, pages 240–247, by permission of the National Society for the Study of Education, Mr. Nelson B. Henry, Secretary.

lets. It should have an acid-resistant top and drawer space for items needed in demonstrations. Properly designed cupboards should be provided for regular storage of materials and equipment.

Several different plans may be used to provide accommodations for laboratory work. One plan is to provide about thirty arm-table chairs in the front of the room facing the demonstration table. Back of the chairs are placed laboratory tables. Movable stools with rubber tips are provided if pupils sit down when doing experiments. Another plan is to equip the room with special-type laboratory tables, such as the Lincoln desk, which permit the pupils either to sit or stand when doing experiments or when they are participating in demonstration-recitation lessons.

Experience has shown that it is more economical to equip a science room with the very best materials. Laboratory furniture bought from reputable manufacturers is usually better than the homemade variety. The plumbing fixtures should be brass or copper, chromium plated, and made for long, hard service. Laboratory sinks should be made of or lined with soapstone. Plenty of drawer space should be available in the laboratory tables.

Cabinets and Chart Cases

A wide variety of objects, specimens, and models are used in teaching science. Cases and cabinets for display and storage of these materials are necessary in the science room. Storage and display cabinets should be equipped with rolling doors that move freely on steel tracks. Adjustable shelves are also helpful. An exhibition case for displaying completed student projects is an excellent motivating device in a science room. A notebook cabinet in which the pupils may place their records of completed projects and experiments is also useful.

Since both homemade and commercial wall charts are being widely used to give a clearer meaning to the ideas of science, a chart case or a rack with rollers is very desirable.

Provisions for Use of Visual Aids

Motion-picture, slide, opaque, and micro-projectors are used in teaching science. Special care must be taken with the windows

so that the science room may be easily and quickly darkened. Boxed-in opaque window shades are generally considered best for this purpose. Proper screens, both "daylight" and reflecting, are required equipment. Electrical outlets must be conveniently placed in the room.

Bulletin Board and Blackboard

Every science room needs a large permanent bulletin board. Its uses are many. Photographs, diagrams, and clippings may be posted on it. It may be used as a place to exhibit exceptional work done by pupils. It is an excellent place to post assignments and notices.

A bulletin board may be made by tacking a piece of plain green denim over smooth pine or a piece of Celotex. Bulletin boards may also be made from Compo-board. A frame around the board will make it more attractive.

Blackboards should be provided along the front and at least a part of one side of the science room.

Aquariums, Terrariums, and Receptacles for Growing Plants

The stockroom should be large enough to provide adequate space for storage. It should also provide enough room for the preparation of solutions and demonstration setups. Cases or cupboards containing a large number of drawers and shelves that will provide a space for everything are necessary. A sink with running water should also be provided.

A darkroom should be planned as an adjunct to the science classroom. It is important for experiments in optics and photography in physics and chemistry. It may also be used for certain experiments in general science and biology, such as those dealing with plant growth and tropisms.

THE PLANNING AND PURCHASE OF EQUIPMENT

The planning and purchase of equipment for demonstration and laboratory work is an important function of the science teacher. Since funds are frequently limited, it is important that these funds

be spent wisely and in many cases that inexpensive substitutes be provided for more expensive apparatus. The following suggestions are offered as a guide for systematic planning and purchasing of science materials.

Determine the Kinds of Equipment That Are Most Needed

Preliminary to the proper selection of equipment, it is necessary, first of all, to ascertain in complete detail the outline of the course of study to be followed in a particular science subject. Once this has been done the types of materials most desirable may be listed under the following heads:

1. Needs for demonstration work
2. Needs for laboratory work
3. General laboratory equipment, such as tools, electrical, water, and gas supply.

Plans for Purchasing Equipment

The science teacher needs an annual budget. It is a legitimate function of the science teacher to show the school administrator that a certain annual expenditure is necessary for efficient science teaching and learning. Depending upon the present condition of the laboratory-classroom, it may be advisable to plan two budgets: one budget made up of annual supplies, such as breakable glassware, chemicals, dissecting materials, and other needed yearly replacements, and another budget consisting of items, listed in order of preference, based upon a long-term plan for building up the science equipment.

It is not advisable to depend solely upon scientific supply houses for science materials. Mail-order houses, dime stores, junk yards, auto graveyards, and local industries are excellent potential sources of physical-science equipment. To make science teaching more life-like, "real" articles such as a real lift pump, an auto jack, or a discarded automobile engine should be purchased in preference to models. In the biological field much interest may be aroused and firsthand information acquired when students have to collect the insects, earthworms, leaves, flowers, and stems which they are to dissect and study.

It Is Desirable to Have a System for Storing Equipment and to Keep Accurate Records of All Science Materials

Science materials should be card-catalogued. A card for each type of equipment should contain the date of purchase, the number of units, the condition of the equipment, and the date when repairs are made. Cases, bins, drawers, and cabinets should be labeled. This system will assist in preventing apparatus and materials from being misplaced or lost.

HOMEMADE EQUIPMENT

Need for Homemade Equipment

Experience in science need not be lacking because of the absence of commercial supplies and equipment. In fact, for a program where one desires to stress pupil activity with application of science principles to everyday living, the use of improvised equipment and devices from the home, garage, and farm may prove more functional than an abundance of purchased apparatus. Pupil experiences in making the needed apparatus for a demonstration or project, by using tin cans, scrap wood, wire, and glass, with the accompanying tools and techniques, may be more meaningful than utilizing "hand-me-down" devices where one has but to pour in the water or press the button properly to operate them. Often the neat case or nicely painted frame or covering of the commercial apparatus hides the real construction and makes more obscure and formidable an already puzzling science principle.

While there obviously are numerous pieces of apparatus and equipment which it is very desirable, if not necessary, to purchase —such as ammeters, microscopes, bunsen burners, vacuum pumps, thermometers, and electric motors—it is surprising how many pieces one can make or improvise or have constructed by pupils. Whether the teacher- or pupil-time could be spent to better advantage is not the question here—much of the useful and needed apparatus for general science, biology, physics, or chemistry can be satisfactorily and inexpensively made, and the making as well as the using of such apparatus can be worth-while pupil experience.

To make such apparatus, whether because of lack of equipment or because the experience in making and using it seems to be particularly desirable, one needs four things not always available in the school science laboratories but not difficult to provide. These are (1) a variety of "raw materials" or supplies; (2) a few simple tools; (3) a suitable working space and arrangements for such "improvising"; and (4) a small working library of practical references.

Variety of "Raw Materials"

When one starts to make provisions for even a small array of teacher- or pupil-constructed devices, he finds need for a relatively wide range and variety of materials. While the usual materials, such as chemicals, glass and rubber tubing, bell wire, flasks, rubber stoppers, and thermometers are needed, numerous other things outside the lists furnished by the laboratory supply companies for the supplies needed to carry out demonstrations and laboratory experiments will be necessary. Aquarium cement, spring brass, Fahnstock clips, asphaltum paint, nichrome wire, ball bearings, DeKhotinsky cement, 6–32 machine bolts, soldering lugs, and copper tubing are only a few which soon are added to the purchase list. When teacher or pupil is making something, particularly during a limited time such as a class period, it is, to say the least, very disconcerting and inefficient to have to lay aside the project for lack of the proper-sized washer or of suitable waterproof cement. The fact that it can be purchased for a few cents at the ten-cent store is not too pertinent when one needs it immediately.

This suggests, of course, that as many as possible of the supplies which may be needed should be anticipated and that a sufficient store be on hand for immediate use.

Often it is possible for the science teacher or pupils to obtain certain supplies from other departments in the school, particularly the fine- and industrial-arts areas. While this may be satisfactory for emergency needs, it obviously is not a long-time policy. If one needs a little glue, or stain, or angle iron, or show-card ink, he usually wants it immediately and wants to use it where and how it

seems most suitable for his particular project. Frequently, overlapping of the needs of teachers from two or three different areas for the same supplies suggests the possibility of pooling orders so that advantage can be taken of lower prices for quantity lots.

A great deal of scrap material can usually be used in constructing and improvising science apparatus. The scrap boxes of the woodworking and metal-working areas of the industrial-arts department often contain small pieces of wood, of copper, brass, and iron sheets or strips, of metal pipes or tubes, of angle iron, and even of wire that are large enough for use in science devices. Bottles, jars, tin cans, and round and rectangular cartons may usually be obtained from the cafeteria or home-economics department. Mailing tubes useful for winding coils or optical devices can be saved by the offices.

Ten-cent stores, hardware stores, auto-supply stores, as well as electrical and radio stores are quite obviously good sources of useful materials at relatively low cost. Junk yards, garages, and gasoline service stations also offer possibilities for picking up old generators, storage batteries, transformers, induction coils, thermostats, cutouts, tubes, ball bearings, and wire. While most of these may not be in a suitable condition "as is," some may be repaired or rebuilt into other devices, or parts and supplies may be salvaged from them, particularly wire. Pupils often show considerable talent and resourcefulness and prove to have "contacts" which the teacher does not have, if encouraged to bring in such types of supplies.

A workable scheme for helping to keep track of such a wide range of supplies is to have each item listed on a single 3 x 5 or 4 x 6 card, arranged in an alphabetical file. On this card can be indicated suitable places where it may be obtained or purchased, the usual unit used in ordering (lb., doz., qt., liter, gross), the unit price, the amount on hand at a certain date, and any other pertinent data. As one continuously adds to his list of supplies, he can write down each item needed on a card, and later file these cards (or make out a new, neater one) in the permanent supply card file. If one has sufficient drawer or cabinet space in which to store such supplies, the location of each item can be added to the

other data on the file card, or a separate file or list giving the location may be kept. The latter is particularly useful for pupil use or where other teachers and classes make somewhat irregular or infrequent use of these materials.

A Few Simple Tools

One cannot make very satisfactory progress in constructing equipment or modifying salvage parts into useful science apparatus without the use of at least a few tools. Perhaps it is obvious what most of these are. Handsaws, including crosscut, rip, back saw, coping saw, and hack saw; claw hammer, ball-peen hammer; mallet, brace for bits, hand drill; wood and cold chisels; screw drivers; folding rules, gas pliers; wire-cutting pliers; tin snips; try square; wood and metal files; planes, auger bits; drills; wrenches; and vise are almost minimum essentials. To this should be added such nearly indispensable items as soldering irons, small c-clamps, oil stones, taps and dies for at least 6–32 and 8–32 machine threads, and emery wheel. Certainly most, if not all, of these should be made available in the science laboratory or shop. One should not rely on borrowing them from the industrial-arts room. For the relatively infrequent use of a few special tools or of power tools, one might count on the usual accommodating co-operation of the school shop.

The small expense involved in providing such a suggested minimum list of tools is more than justified by the savings resulting from the construction of science apparatus and by the learning experiences of pupils and teacher.

Suitable Working and Storage Space

Supplies and tools are of little use without a suitable place to use them. This certainly does not need to be large or elaborate. It may be a small closet or room near the science laboratory. The science preparation room might be arranged for this purpose. Storage and working space might be provided in the science laboratory. Or a combination of two or all of these might be the appropriate solution in some situations. One or more tables to which a vise could be attached, with a work table or two along the wall

where outlets for electricity, gas, and water could be provided, would pretty well take care of the needed working space.

The problem of storage, because of the large number of small items, seems best solved by the use of a number of small drawers or boxes, or other type of containers, such as glass jars, or a combination of these. If cabinets or shelving rather than a fairly large number of small drawers are available, the use of a series of different-sized drawers may be quite satisfactory.

With whatever arrangement for storage that is provided, labels should be used on each drawer, box, or container. It is much better to letter them with a lettering pen in rather large size than to type them. The provision of an alphabetical index, either on cards as previously suggested or typed or mimeographed, is a device which will save much time and confusion in finding and replacing supplies. This is particularly valuable where different groups of pupils make use of the supplies semester after semester —though even the teacher, who set it up in the first place, may forget whether the sealing wax was placed in the box with the paraffin wax and candles or in the one with glues and cements.

Practical References

Unless one has a very great deal of resourcefulness and previous practical experience with tools and devices, he will find considerable need and use for references which give suggestions on what to make and how to make it. Such references are particularly needed if pupils participate in working on these or related projects. One will need at hand references which will give information about such things as kinds of glue for certain purposes; chemical formulas; size of drills; size, resistance, and current-carrying capacity of wire; circuits for different devices; how to drill a hole in glass; soldering, brazing, polishing. The teacher with a little ingenuity can, of course, make plans for his own improvisations, modifications, and special apparatus. However, over a period of a hundred or more years a vast array of interesting and useful inexpensive demonstrations, laboratory experiments, projects, and special equipment have been devised and described by resourceful teachers. Recent as well as back issues of such a magazine as

School Science and Mathematics contain a wealth of suggestions on this phase of science teaching. The catalogues of apparatus companies are particularly suggestive. Many trade journals also contain suggestions for making useful apparatus, as do popular science magazines. Of course, there are also a great many books which treat one or more aspects of this practical phase of constructing devices and working out demonstrations.

VISUAL EDUCATION

TECHNIQUES FOR USING BULLETIN BOARDS

A well-constructed bulletin board can provide variety and interest in learning experiences. If bulletin boards are used for the sole purpose of posting pictures to make the room attractive or displaying administrative notices, their function in learning situations is extremely meager. Bulletin boards may be constructed to teach scientific facts, to review information which has been learned, to test the information students have, to make application of information to new situations, to extend students' knowledge of various topics, to apply the information of topics to current events, to display student work for the purpose of developing standards for the group, or to present information about topics not included in the textbook. A variety of pictures, diagrams, charts, drawings, and other kinds of material may be used to construct bulletin boards. A bulletin board should always have a topic, a problem, or something to emphasize the main idea it is organized to teach.

Example of a Bulletin Board Used for a Demonstration

The teacher posted on the bulletin board a variety of labels from different kinds of plant food products which were designed to be dissolved in water. The claims of the products were emphasized by an arrow which pointed from each label to a test tube that contained a solution made with the product. A wheat seedling had been placed in each one of these test tubes. One of the test tubes contained tap water for a control. Behind the test tubes graph paper had been mounted so that the length of the roots could be recorded each day. The questions on the bulletin board were these: "What plant food product would you purchase?" "What is the effect of plant food products on the root growth of plants?" "Are the claims of the advertisers justified?" It was soon apparent which plant food products were the most valuable to use to stimulate root growth in plants.

Example of a Bulletin Board to Be Used to Review Information

The following pictures were placed on the bulletin board by one teacher: pictures which showed light coming from luminous objects; pictures of light coming from reflected objects; pictures of objects which are useful to man because they reflect light. Students were asked to do these three activities: (1) list the luminous objects, (2) list the objects which are sources of reflected light, and (3) describe why the objects which reflect light are useful in this community. The students corrected their own papers by reviewing the textbook.

TECHNIQUES FOR USING CHARTS

The publishers of charts try to get as much information as possible upon one chart so that it will be useful to a variety of different teachers and in a number of different situations. When charts are used as a source of information, students should recognize that the title of the chart describes its purpose. They should have emphasized for them the part of the chart which provides information for the topic they are studying. Charts may be used to review information, to teach new information, or to apply information already learned to new situations. Some teachers have used charts as a testing device.

If diagrams or figures on charts are so small that it is difficult for the class as a whole to see them, it is better not to use the charts unless provision is made for each student to see. An opportunity should be provided for students to examine and discuss charts before they are used as a part of the teaching technique. Students may do this before or after class, or time may be provided in the class for students to study the charts while they are working individually on exercises in the Companion Book. It is essential, if charts are to be learning activities, that the students do the thinking and the work with the charts. The teacher who lectures, points out, and has the best view of the chart is the one who is really benefiting from the experience. The students should do the answering of questions, the pointing, the identifying, and the recording of information.

SUGGESTIONS FOR A CURRENT FILE

At the beginning of the year the teacher should organize a file according to the topics in the book which are to be studied. Students should be encouraged to contribute clippings, pictures, articles, and other material to this file. As the material in the file is used it should be evaluated so only the best things are retained. The file will be small at the beginning but it will be an accumulative process which can result in much valuable material to be used on bulletin boards. Many parents are happy to contribute old issues of their magazines for this purpose.

TECHNIQUES FOR USING DEMONSTRATIONS AND EXPERIMENTS AS LEARNING ACTIVITIES

For some reason many science teachers prefer to think of demonstrations and experiments as opportunities for them to display their skills at manipulating apparatus and "making things work." The students sit in boredom while the teacher has all the excitement. If demonstrations and experiments are for the students and for their learning, then opportunity should be provided for them to participate in them. Not every demonstration or experiment can be a success, and teachers should not feel embarrassed or inadequate if the demonstration fails; neither should they chastise students for failure to have a successful demonstration or experiment each time. All individuals have a natural curiosity to feel, smell, taste, hear, and see. Whenever possible the five senses should be allowed to operate for the gathering of information. The important points of emphasis are care, caution, and wisdom in deciding what to touch, what to smell, what to look at, what to taste, what to listen for, and what to feel. It is very easy to develop within students a pride in the care of equipment if they are allowed to satisfy their curiosity in connection with it. One science teacher said that she was never able to use the laboratory provided for her science class because the students did nothing in the laboratory but destroy equipment and waste their time. The wrong standards had been developed with these students and the purposes of demonstrations and experiments had never been

clearly explained. Perhaps the demonstrations and experiments selected for them to learn by were meaningless and useless to them. Students enjoy figuring out what to do with materials if they are given the opportunity and if it is clear to them the purpose for which these materials are to be used. A good science teacher will often introduce a demonstration or experiment by asking the students to identify the materials that are being used. Before anything is done students should have a knowledge of the things that are used to accomplish the demonstrations and experiments. The second thing the science teacher does is to explain what kind of information can be obtained from the demonstration and experiment or to write on the board the questions which the demonstration will help to answer. When these things have been done he may ask the students this question: "How can the materials we have be used to answer our question?" Students enjoy trying out their ideas in the arrangement of the equipment. If the arrangement a student makes is not identical to, but as good as the one the science teacher had in mind, the student should be allowed to use his arrangement and he should be complimented for thinking of it.

The demonstration or experiment should be done once so that questions which students have may be answered. The teacher will discover if it will work and the excitement of watching will be over. It should then be performed again so that observation may be directed to certain results which will help to answer the problem. A good science teacher, in addition to using the demonstrations and experiments suggested, will think of similar demonstrations and experiments which emphasize the same information. An excellent exercise to discover if students can recognize the similarities in many different kinds of demonstrations and experiments can be done by providing a series of demonstrations and experiments which emphasize the same point. The students are asked to record on a chart what is similar, what is different, and the result of each demonstration or experiment. The result should be stated in the form of a scientific fact. In addition to these things a student should be urged to write the answer to the questions: "What happened?" and "Why did it happen?" Science

teachers who use this technique discover that some students can recognize only the differences which exist; others are able to recognize the similarities; and some are immediately able to recognize the relationships which exist among all the demonstrations and experiments.

TECHNIQUES FOR USING FIELD TRIPS AS LEARNING ACTIVITIES

Field trips often become pleasure excursions that are more like picnics than they are like learning activities for the purpose of getting information. Before each field trip students should make a list of the standards they have agreed to adopt during the trip. At the end of each trip they should evaluate how well they have achieved those standards. They should have a list of questions which are to be answered during the field trip or they should know that the purpose of the field trip is to see what can be discovered and to bring back information which will help to answer questions.

Science teachers often expect the impossible on field trips. They expect students to be quiet, to listen, and to be interested in things the teacher is interested in. If the field trip is of importance to the student and he is interested in getting the information that can be acquired by the field trip, the teacher will not have to worry about noise or disturbing activities. The important thing is to listen to what children say when they talk rather than to concentrate merely upon the fact that they are talking. Children can contribute a great deal of education to each other if teachers don't prevent the process. Field trips should be enjoyed. There should be some opportunity to be informal and to make contributions to the enjoyment of living as well as to the intense emphasis upon learning from observation. During a field trip a teacher is often able to sit down with his students about him and to make suggestions and discuss behavior important to the group that it is not possible to discuss in the classroom because of the formal situation. A teacher must expect active youngsters to be active when they are outdoors. He should also expect them to

learn many things in addition to those for which the field trip was planned.

When field trips are taken to places in the community and people are asked to devote their time to making explanations for students, the group should not tolerate a discourteous student. Many such field trips are a waste of time because students cannot hear, because the trips last too long, because the students cannot concentrate upon what they are seeing, or because the person who is answering the questions talks "above the heads" of the students. A well-organized field trip for which the teacher has made previous preparation by discussing with the person in charge the kinds of students who will attend, the information that they wish, and the difficulties of the physical layout in which the field trip is to be taken will be rewarded by having a real learning activity. Excursions in the same pattern as a Cook's Tour are useless in a science class. Groups of students can take these excursions on week-ends without wasting the time or the effort of the science teacher.

TECHNIQUES FOR USING FILMS

Films are often used as an entertainment feature in education. If films are to contribute information which will help solve problems, teach science subject matter, or apply subject matter to many situations, the teacher must make careful preparation for the use of this kind of visual material. A teacher should, if possible, preview the film before it is used with the class. If it is impossible to do so, the class and the teacher may preview it together, which will mean that it will have to be shown twice. Following the preview, the teacher should make clear the part of the unit to which the film is related. He should also suggest the kind of information that can be acquired from the film. He should make a list of questions to guide the observation of children as they look at the film. After the film has been shown, opportunity should be given for the students to answer these questions. If possible, they should see the film again so that they can evaluate the correctness of their own answers. If the film is used for recreation and enjoyment of the class, these purposes should be apparent to the class before the film is shown.

Films for How and Why Explorations

In the chart below are listed certain selected films which may be useful to help teach the information in the various units. Although the films are listed for separate units, they may be used as desired by the teacher. The numbers to the right of the titles of the films refer to the list of companies which follows. Only one company is listed as a distributor for each of these films. Most of the films, however, are available from ten or more distributing companies.

Unit	*Film*	*Company*
Scientific Identification	On to Jupiter	5
Light	Behavior of Light	4
	Nature of Color	3
Atoms for Energy	Atomic Energy	4
Your Skin	Skin	4
Summer in the Forest	Fire Prevention	4
	Plant Growth	4
	Roots of Plants	4
You and Your Food	Digestion of Foods	4
	Foods and Nutrition	4
Weather and Flight	Exploring Space	7
	Earth in Motion	4
	World We Live In	6
	Earth and its Resources	6
	Atmosphere and its Circulation	4
	Work of the Atmosphere	4
	Aerology; Thunderstorms	2
	Weather	4
Electricity	Principles of Electricity	5
	Excursions in Science	5
Fire for Man	Fire	4
	Fuels and Heat	4
Temperature Control	Distributing Heat Energy	4
Your Teeth	Our Teeth	6
Engines on Tracks	Diesel—The Modern Power	5
Water on the Land	The Desert	1
	The Seashore	1
	The Mountains	1
	The Valley	1
	Ground Water	4
	Water Cycle	4
Exploring an Ancient City	Smithsonian Institute (Inspection Tour)	7

Film Distributors

1. Barr, Arthur, Productions, 6211 Arroyo Glen, Los Angeles 42, California.
2. Castle Films, 30 Rockefeller Center, New York 20, New York.
3. Coronet Instructional Films, 65 E. S. Water Street, Chicago, Illinois.
4. Encyclopedia Britannica Films, Inc., 20 N. Wacker Drive, Chicago 6, Illinois.
5. General Electric Company, Publicity Department, 1 River Road, Schenectady 5, New York.
6. Knowledge Builders, 625 Madison Avenue, New York 22, New York.
7. Teaching Film Custodians, 25 W. 43rd Street, New York 19, New York.

TECHNIQUES FOR USING LANTERN SLIDES AND FILM STRIPS

Lantern slides and film strips may be used by a teacher for several purposes. They may be used to review important ideas, to test the comprehension of students, or to teach a particular concept in science; or they may be used as new situations to which students must apply information they have learned. As the slides are viewed by the students, the teacher should have prepared a series of questions to direct the attention of the students to the main ideas which can be obtained from the slides in relation to the problem or topic which they are studying. Many slides shown in science classes are meaningless to students because the students do not know the relationship of the object they are looking at to the things they have been studying. This is particularly true of cross sections of tissues. One other difficulty is the concept of the relationship of size of the actual object and the apparent size of the object as shown on the slide. A teacher should always emphasize the degree to which the object on the slide has been magnified. Many science students make their own slides. Kits for this purpose can be obtained from many of the supply companies. One of the dangers in using visual materials is that

students become so interested in certain ideas that are unrelated to the problem that the information is never obtained which is needed to help them with their problems. If there is a variety of questions which are "off the topic," the teacher should provide a special time to answer these questions, or the questions may be answered at once in order to satisfy the immediate curiosity and the slides shown another time so that the students can obtain the information they need.

TECHNIQUES FOR USING MICROSCOPES, MODELS, AND OPAQUE PROJECTORS

The directions given for the use of slides, charts, films, and bulletin boards are applicable to the use of microscopes, models, and the opaque projector. If a teacher has very little money to spend on equipment for the science room, an opaque projector in which slides can also be shown is one of the most valuable pieces of equipment to enrich the learning activities of students. Pictures in books, printed material, diagrams, pamphlets, and many other kinds of material can be projected upon the wall with an opaque projector. In the junior high school, it is not essential to have a microscope for each student. The skill required to operate a microscope can be learned when the student takes other high school sciences. A few microscopes which can be used to show certain prepared slides which are most meaningful in relation to the units can be set up in the room and students may view them under the direction of the teacher while other students are working on exercises in the Companion Book. A microscope which may be adjusted and used with a light bulb to project a slide upon the screen is most useful for large classes. Many models are not valuable for work in science classes in junior high school unless they are sources of information which cannot be obtained in any other way. They are very expensive and a teacher should be cautious to buy only those which are most essential. It is often possible to use actual material rather than models.

TECHNIQUES FOR USING INTERVIEWS

Many science teachers feel themselves successful if they are able to get out of teaching classes by having a variety of guest speakers. The purpose of the speaker is to "take up the time." Before a speaker comes to a group he should know the questions that the students want answered. The teacher should have discussed the answers with him so that he can make suggestions and should have briefed him as to the background of the students and their abilities to understand what he is saying. The purpose of interviews is not to compliment the person who comes but to provide information that the students could not otherwise obtain. The class should always send a letter which thanks the speaker for contributing his time. The teacher should make an effort to thank him personally. The teacher should also carefully evaluate his effectiveness with the group. Those speakers who are ineffective should not be asked to return.

Students should have an opportunity to discuss with the teacher the information that should be recorded from the interview. While the speaker is there they should listen and ask questions if he permits, but their time should not be devoted to the taking of notes since junior high school people have not developed the skill of concentrating upon note-taking and what the speaker is saying at the time. It is better for them to concentrate on what the speaker is saying. The teacher should be the one who does the note-taking so that he can re-emphasize the main points which the speaker makes.

TECHNIQUES FOR USING LIVE MATERIAL

A science teacher who stimulates genuine interest and curiosity in the environment finds himself with a great deal of live material in his classroom. One of the most repulsive things in science rooms is the amount of dead material that is in various stages of decay and putrefaction. Containers become filthy and impossible to clean. The room is repulsive to the students who must study in it and to others who may come into the room. The purpose of keeping live material in a room is not to discover how long

it must be dead before someone will remove it, but to enjoy and learn through observation while it is alive.

In schools where money is not plentiful and it is impossible to buy a great deal of equipment which facilitates the handling and care of live material, a teacher and the students may have to make their own containers. Some science classes have used science programs in the community as a means of raising money to purchase equipment essential to the care of living things. Any reputable biological supply house lists in its catalog a variety of aquaria, terraria, and cages.

Any living thing kept in a science room should have adequate air, water, sunlight, food, and a clean place to stay. If such things as pigeons, chickens, or ducks are to be kept in a room, their cages should be cleaned regularly and they should be provided with the essentials for healthy bodies. Rats, mice, guinea pigs, hamsters, and rabbits need daily care. Rather than having too many things in the room at once, so that all the time of the science period is spent in the care of them, it is better to have a pet show or a demonstration of live material once a month or once a semester. Many of the biological supply houses have leaflets which will be sent free of charge to inform the teacher of the best ways to keep live material in the room. Students should never be permitted to tease, to be cruel to, or to destroy live material.

A special cabinet, table, or section of the room should be devoted to a display of the material that accumulates. By the end of the school year a vast amount may be on hand. Teachers who try to save all the material that is brought in usually find they do not have sufficient room for its adequate preservation. It is better to clean house at the end of each year and to start afresh with new collections which are meaningful to the students who bring them in, rather than accumulating vast amounts of material which are available each year in great quantity. This is particularly true of rocks and insects.

A great deal of teaching of scientific information can be done through the use of live material if a teacher provides the opportunity for it. Questions such as these can be answered by observation:

1. What are its characteristics?
2. What does it eat?
3. Where does it live?
4. What other animals is it related to?
5. What do we use it for?
6. Is it harmful or beneficial to man?
7. What do the young look like?
8. In what other parts of the country is it found?

Children may also be stimulated to write individual reports or to do individual research problems about the live materials. If a student goes to the trouble of contributing something to the science room, he should have an opportunity to tell about it. In the junior high school he should add to the information that he has acquired incidentally, and obtain information that is the result of special interest in the material.

TEACHING PROCEDURES

SUGGESTIONS FOR TEACHING THE UNITS IN HOW AND WHY EXPLORATIONS AND THE USE OF THE EXERCISES IN THE COMPANION BOOK

SCIENTIFIC IDENTIFICATION (Pages 5–14)

Science Concepts:

Fingerprints have different patterns of ridges and depressions.
Each fingerprint is different.
Depressions and ridges of the fingerprints are part of the skin.
Fingerprints cannot be changed.
Individuals have characteristic types of blood.
Human blood may be typed into four different groups.
Blood can be divided into two parts, plasma and cells.

Introduction

The units in the science book, How and Why Explorations, have been written as a result of working with children in science classes. The organization of science facts and the application of these facts have been meaningful to these children. In introducing this first unit the teacher is insured that if students do nothing but read the text and complete the exercises in the Companion Book they will be doing things that other students have enjoyed doing. Many teachers wish to make more of a contribution to their classes than the assignment of textbook pages and companion exercises. Since the students are not able to see the unit in its entirety before they have completed their work, it is the responsibility of the teacher to indicate to them the purpose of the unit and the kinds of things that can be learned as they work. The overview lesson offers an opportunity to make this unit practical for children in a particular community. In order

to do this it is necessary for the teacher to understand the materials with which he will work.

Materials Available in the Textbook:

1. Pictures
   - *a.* Science classroom (page 4)
   - *b.* Fingerprints (diagram and photographs, page 8)
   - *c.* Men comparing fingerprints (page 9)
   - *d.* Processes of fingerprinting (page 10)
   - *e.* A fingerprint record (page 10)
   - *f.* Composition of the blood (page 12)
   - *g.* Anti-A and Anti-B (page 12)
2. Charts
   - *a.* Reaction of type of blood to Anti-A and Anti-B (page 13)
   - *b.* Characteristics of the blood types (page 13)
   - *c.* Pictures of the blood types (page 14)
3. Introduction (pages 5 through 7)
   - *a.* Discussion of fingerprints (pages 8 through 11)
   - *b.* Discussion of blood types (pages 11 through 14)

Materials Available in the Companion Book:

1. Introduction (page 1)
   - *a.* The fingerprints of the class (page 2)
   - *b.* The toeprints of the class (page 3)
   - *c.* Comparison of the work of the scientists and the work of the police (page 4)
   - *d.* Problem-solving exercise (page 5)
   - *e.* Application to birth certificates (page 6)
   - *f.* Recognition of similarities between fingerprints and blood types (pages 7 and 8)

An examination of these materials reveals the kind of information, its application, and the learning skills to be developed in this first unit. The overview lesson should be planned so that each one of these becomes an important part of the discussion. These ideas should form the foundation upon which the study guide is constructed.

Suggestions for the Overview Lesson

1. Draw a picture of the school building on the blackboard. Ask a student to draw an arrow which will indicate the direction in which one would have to walk to reach the police station.

2. Ask a student what is on the chalk that the police might be interested in. In what other parts of the room would a person find fingerprints? Ask the children to look on their desks, papers, and other articles they have handled to see if they can locate a fingerprint. Turn to page 8 in How and Why Explorations and ask the question, "Why can't you see fingerprints like those in the pictures?"

3. Ask the students to look at the picture on page 4 and then ask these questions: "If a policeman were in this room getting fingerprints what do you believe he would use? Why do you think he would want the fingerprints that are in this room? What would he do with the fingerprints after he got them? How could he find the person who had made the fingerprints? How would he know he had the right person? In what way would this protect all the students in this room? Do you know of any other characteristics which people use to identify people? Why is it important to have policemen who know how to collect and record fingerprints?"

The answers to these questions will indicate to the teacher how much the students already know about fingerprinting and the relationship of the police station to the identification of individuals. Ask the students to do the first exercise on page 1 of the Companion Book.

The Study Guide

The first responsibility of the teacher is to help students recognize and make a good study guide. A good study guide always begins with a problem. The problem should be one that is important to the student and to society. Following the main problem should be a series of smaller problems the answers to which will provide the information with which to answer the main problem. The third part of the study guide consists of the activities that are necessary to provide the information with which to answer

the problems. The fourth part of the study guide consists of the information or the evidence that has been collected. The fifth part consists of sentences which are made as a result of analyzing the information in relation to the problems and synthesizing this information. The sixth part of the study guide consists of the answers to the questions and the problem.

In making the study guide ask the students to read rapidly pages 5 through 14 and then ask this question: "What is the most important problem that can be answered with the information in this unit?" The problem should be worded something like this: "How do fingerprints and blood types help the police solve crimes?" The second question should be: "What are the problems that will have to be answered before this main problem can be solved?" These are suggested: (*a*) "What are fingerprints?" (*b*) "What are blood types?" (*c*) "How do the police use fingerprints?" (*d*) "How do the police use blood types?" (*e*) "How do these uses protect people in the community?"

Suggested Procedures

1. Read pages 5 through 14 in How and Why Explorations.
2. Study the pictures on these pages.
3. Do the first exercise in the Companion Book.
4. Make fingerprints of the class (Companion Book, page 2).
5. Make toeprints of the class (Companion Book, page 3).
6. Compare the work of scientists and the work of police (Companion Book, page 4).
7. Identify the problems of the scientists (Companion Book, page 5).
8. Apply your information to birth certificates (Companion Book, page 6).
9. Compare the similarities and the differences between fingerprints and blood types (Companion Book, pages 7 and 8).
10. Make a five-columned chart. At the top of each column write one of the sub-problems. In each column write the information that you have gathered by reading, looking

at pictures, and doing the exercises in the Companion Book that will help to answer the problem.

11. Study your chart. List in sentence form the main ideas which help to answer the main problem.

The Evaluation of Student Work

There are many ways to evaluate the work that students do in science. Since one of the objectives of science education is to help students develop the skill of collecting and recording accurate evidence in relation to problems, this first evaluation can be used to indicate to the students how well they are able to do this. Divide the students into groups of five. Appoint a chairman for each group and ask him to call on each student to read the answer to the main problem. The group should then discuss the answers that are read to decide if they answer the problem. As a result of their discussion students should re-write the answers to their problems, if they can be improved. Several of these answers should be read aloud before the class so that all students may benefit from the variety of original answers the students have written. It is important to stress that a correct answer does not need to be stated in a certain way, but that there are many ways of stating the same idea. One question to use to test the correctness of the answer is this: "Does my answer explain the relationship between fingerprints and blood types and the work of the police in the community?"

It is well to review with students the main activities which they have completed in order to answer the problems. If the list is put on the board it should include the following items: Reading, observing, recording information, making comparisons, making applications, making a study guide, analyzing, synthesizing, making a generalization or conclusion, testing the generalization, and refining the generalization.

Suggested Activity No. 1:

This activity may be given as an assignment to be done at home or as work to be done during the class period. The teacher presents this situation to the class: "One morning I went into a classroom. I discovered that a pane of glass had been broken.

Some of the glass was on the floor of the classroom. As I examined it I noticed there were bloodstains on the glass.

"How would you discover who had broken the glass? How could you prove who had been responsible for the accident? Pretend that you are a policeman and that you are going to use all the scientific procedures that you know in order to definitely identify the person who broke the glass."

Suggested Activity No. 2:

If you can obtain a passport from someone who has traveled outside this country, show the passport and ask the students to write the answer to this question: "Why are citizens of the United States requested to have their fingerprints recorded when they travel abroad?"

Suggested Activity No. 3:

Ask students to record the fingerprints of the different members of their families. This should be done in a similar manner to that suggested on page 2 of the Companion Book. Use these fingerprints to make a bulletin board of family portraits.

Suggested Activity No. 4:

Ask one of the policemen who is a fingerprint expert in your community to talk to the class.

Suggested Activity No. 5:

Arrange for a trip to the police station.

Suggested Activity No. 6:

If possible, obtain some blood from a hospital. Examine a drop of it under the microscope. Allow the blood to separate into plasma and blood cells. Pour some of the plasma into another test tube. Examine some of the plasma and some of the blood cells under the microscope.

Suggested Activity No. 7:

Invite one of the nurses from a hospital to explain why the

typing of blood is important for patients who are to receive blood transfusions.

Many of these suggested activities will demand the use of the eighteen facts listed on page 7 of the Companion Book. In addition to these facts the teacher should review the materials which the students have used to evaluate their achievement of the following important skills: (1) reading to select important information, (2) accurate observation, (3) application to coming events, (4) the ability to recognize problems, (5) the ability to recognize similarities and differences, and (6) the ability to analyze information in order to solve problems.

Since these are the main skills that students will need in order to complete the rest of the work in the book, individual conferences with students should be arranged.

LIGHT (Pages 15–38)

Science Concepts:

Light comes from different objects.
Luminous objects must be very hot before emitting light.
Objects reflect light.
Light moves in waves.
Light waves move in a straight line.
The direction in which light waves move may be changed.
Light may be reflected.
Light waves are radiated in all directions.
Light may be diffused.
Light may be refracted.
Solid substances may be opaque, transparent, or translucent.
Light waves are different lengths.
Color depends upon wave length of light.
The angle of incidence is equal to the angle of reflection.
Light may be focused.
Some substances are sensitive to light.
Light changes silver chloride to metallic silver.
Electricity produces heat.
Light waves may cause materials to be fluorescent.

The first unit of How and Why Explorations develops the idea that science is important in a community. The application of the scientific information in the first unit suggested that a community is improved as it uses more and more scientific procedures to protect its people. Children of junior high school age are curious about many things. The attention span is short. For this reason the units in this book do not follow a logical organization. Students in our public schools are interested in a great variety of scientific topics. Different students are interested in different things. For this reason the unit on light follows the unit on scientific identification. It continues the theme that science is important in a community. The first section of the unit, pages 15 through 21, presents the basic scientific ideas about light. The rest of the sections in this unit show the application of this information to many things that are used in the community. Mirrors and lenses, instruments, photography, light in the home, and light in the community form the bulk of the unit. One of the main purposes of this unit is to teach a few basic scientific facts and then to make many applications of these facts so that a student can use them in his everyday living.

If students are forced to always use the same patterns of study in the junior high school, they may become bored. Lack of interest, which is often evidenced in high school science courses, is a result of dull routine in teaching. Although a teacher's objective may be the development of skills of problem solving, it it is not necessary to make students practice these each day in order to perfect them. It is suggested that the study guide and the overview lesson be eliminated as a procedure in studying the unit on light.

Much of the ability of a student to solve problems is related to the reading skills he has developed. Unit 2 provides an excellent opportunity for a teacher to help the class read scientific information. The following procedure is suggested:

Suggested Procedure

1. The teacher reads the first paragraph on page 15.
2. Ask a student to read the items in List 1 on page 15.

3. Ask another student to find the sentence on the page which explains why all of these things belong in List 1. He should read the following sentence: "All the objects in List 1 are luminous objects."
4. Ask the students to read the second paragraph on page 15. Ask a student to answer this question: "What are the characteristics of luminous objects?" He should list these three characteristics: (*a*) they are sources of light, (*b*) light comes from them, and (*c*) they must be hot before they will give off light. Ask the students to list the luminous objects in the classroom.
5. On another page in their notebooks have the students list luminous objects in their homes. Ask them to make a third list of luminous objects in the community.
6. Ask a student to read the items in List 2. Ask another student to read the sentence on page 15 which explains why all of the items in List 2 are similar. He should read the following sentence: "All of the objects in List 2 reflect light." Ask a student to tell the characteristics of objects which reflect light. He should make these statements: (*a*) light comes from them, (*b*) they have no light of their own, and (*c*) light must come to them from a luminous object before they can reflect light. Ask a student to answer this question: "If there were no luminous objects in the world, where would light come from?" On a page in their notebooks ask the students to write the answer to the question at the top of page 15.

Suggested Activity No. 1:

Some students may enjoy using an encyclopedia or other source books to get information to make a report about the following questions: "How does a firefly produce its light?" "How does an electric eel produce light?" "How does a firecracker produce light?" "Why do you see light when a volcano erupts?" "Why does an electric stove produce light?" "Why do some watch dials glow in the dark?" "Why does some jewelry glow in the dark?"

Suggested Activity No. 2:

Organize a science table on which students place luminous objects. Have each of the objects arranged so that light could be reflected by another object.

How Does Light Move?

The next section of this unit gives the student experience in selecting problems in relation to experiments. Many times students perform experiments with no conception of the problems which the information obtained from the experiments will solve.

Suggested Activity No. 1:

Ask the students to read pages 16 through 18. As soon as they have read the pages have the equipment available so that a group of students may demonstrate the three experiments to the rest of the class. After they have demonstrated their experiments and have discussed them they should do the exercise on pages 9 and 10 of the Companion Book. It may be necessary for them to repeat the experiments in order to complete the exercise.

Suggested Activity No. 2:

Ask the students to read the paragraph in the middle of page 10 of the Companion Book which begins with the question: "What have you done?" Ask them to turn to the study guides which they made for Unit 1. As they review these study guides, have them write the answers to the following questions: "How were the important problems for Unit 1 selected?" "What were the main ideas of the problems?" "What were the important relationships?"

Suggested Activity No. 3:

Ask the students to do the exercises on pages 10 and 11 of the Companion Book. These exercises stress safety habits which should be practiced each time equipment is used in the classroom. Although the equipment for these experiments is relatively inexpensive and the experiments are simple, accidents can occur. It is better to develop good safety habits with simple equipment than it is to neglect them until more serious accidents occur.

Suggested Activity No. 4:

Assemble the materials for the three experiments again. Ask one student to indicate from what the light is being reflected. The students should then do the exercises on pages 12 and 13 of the Companion Book.

Suggested Activity No. 5:

The next exercise in the Companion Book demands an exploration of the community for information. The students may be divided into teams and each team can read its list the following day in class. The rest of the class should act as judges to determine if the correct information has been placed on the chart on page 14.

The exercises on pages 15 through 18 of the Companion Book are designed to review and apply the information the student has learned from the experiments and the reading that he has done. He may need to refer to his textbook in order to complete these exercises. If there is time to provide individual study periods during the class hour, the teacher should check with each student to answer questions and help the students with these exercises.

Color

The section on color may be familiar to some students. The exercise on page 19 of the Companion Book can be used as a test exercise to discover if they understand the material on pages 19 to 21 of the textbook.

Suggested Activity:

Students may enjoy constructing a color wheel as shown on page 20. It can be placed on the bulletin board and whirled by hand. They may also enjoy doing the two demonstrations which were suggested on page 21.

Mirrors and Lenses

This section can be studied by discussing the diagrams and the pictures which appear on the pages. The following questions

should be asked about the picture in the upper left corner of page 22: "Why does this diagram belong in a section about mirrors? What does the tennis ball represent? What do the arrows represent?" These questions should be asked about the picture in the middle of the page: "Why is this picture important in a section of the science book? What does the tennis ball represent? What does the tennis racket represent? Why didn't the picture show the man returning the ball instead of missing it?" The picture on the bottom of page 22 shows a candle reflected in a mirror. In the two diagrams to the left which line represents the mirror? What do the arrows represent? What does the diagram on page 23 help to explain? Ask students to draw on the blackboard the lines which represent mirrors in the diagrams. By studying the diagrams what explanation can they make of the way light waves behave when they strike a mirror?

After the students have answered these questions, have them read the material on pages 22 through 24 and correct their answers as they read. Page 25 presents information about different kinds of lenses. Have the students compare the diagrams on page 25 with those on page 24. What is the main difference between these two diagrams? They should recognize that in the diagram on page 24 light does not go through a mirror but is reflected from it. On page 25 the light goes through a lens and its direction is changed as it moves through. When they have read page 25 ask a student to answer this question: "What happens to light rays as they move through a lens?" With this information they should be able to do the exercises on pages 20, 21, 22, and 23 of the Companion Book.

Instruments

Before the students read pages 26 and 27 have them do the exercises on pages 24 and 25 of the Companion Book; then have them write the answers to these questions: "How are telescopes and microscopes similar?" "How are telescopes and microscopes different?" Some of the students may have simple microscopes or telescopes that they would be willing to bring and demonstrate to the class. Have one student explain parts of a telescope and

how they function. Have another student use the microscope, explain the parts, and show how they function.

Photography

The section on photography may be used as desired by the teacher. These are suggested activities for this section:

1. Have students answer the main questions in boldface type.
2. Some students may enjoy making a pinhole camera.
3. Students may enjoy demonstrating the developing or the printing of pictures.
4. A student may exhibit his camera, its parts, and show how they function.

The last two sections in this unit are on light in the home and how light can be produced without heat. The teacher may read these sections aloud to the students and discuss them as he reads. An interesting evaluation that children sometimes enjoy as a type of test is called "The Listening Quotient." After the teacher has read and discussed these pages he reads them once again but omits a word from certain sentences. Students number their papers to correspond to the omitted words. For example, the teacher may read this sentence: "Campfires, candles, oil lamps and gas lights are all examples of ______ ways of lighting the home." The student writes on his paper the word which belongs in the blank. He numbers this No. 1.

As an evaluating activity for this section have the students draw a map of their community as they imagine it might have been before it was settled by man. In a series of maps have them indicate the first thing that came into the community which made more light than had been there before and was a result of something that man had done. The first map might show a bonfire made by a group of people who were camping as they moved westward. The second map might show fires in fireplaces and candles. The last map should include electric power plants; street lights; lights on streetcars, taxis, automobiles, in stores, and in homes. Students should be able to write the answer to this question: "How has the community been improved by the light which man has added to his community?"

ATOMS FOR ENERGY (Pages 39–45)

Science Concepts:

Elements may combine with each other.
The smallest particle of matter is an atom.
Atoms may combine with like atoms.
A molecule is a combination of atoms.
Atoms of different atoms may combine.
All materials are composed of atoms.
A molecule is the smallest part of a compound.
Atoms contain protons and electrons.
Different atoms have different numbers of protons and electrons.
Like atoms have like numbers of protons and electrons.
Protons have a positive charge of electricity.
Electrons have a negative charge of electricity.
Electric current is electrons in motion.
Electric energy is produced by moving electrons.
Energy is released when the nucleus is separated.

In this unit six questions are answered:

1. What are elements?
2. What are molecules?
3. What are compounds?
4. What are atoms?
5. What is the relationship among an atom, an element, a molecule, and a compound?
6. Who are some of the scientists that have contributed information about atomic energy?

In addition to the answers to these questions, the student is introduced to the symbols that scientists use to identify different elements. They are also introduced to symbols for molecules and to some of the simple formulae. Basic ideas necessary to the understanding of atomic energy are introduced in this section.

The exercises in the Companion Book are designed to relate the work in the first two units to this unit, "Atoms for Energy." The first exercise in the Companion Book helps the student to understand the relationships that exist between light and ele-

ments. The second exercise helps him identify some of the common elements and compounds with common everyday events. The exercise on page 29 is a vocabulary review of the words he has learned in the first two units. In addition there is a list of elements and their symbols which he uses to identify the ideas he has previously learned. These ideas begin the basic work which is essential to recognition of the differences and similarities between energy and matter.

The first unit was studied by using a study guide; the second unit was studied by discussion with the teacher; and the third and fourth units may be studied by the students working individually with the textbook and the exercises in the Companion Book.

THE METRIC SYSTEM (Pages 46–47)

Science Concepts:

The metric system of measurement is generally used by scientists.

The meter is a measure of linear distance.

The gram is measurement of weight.

The liter is measurement of capacity.

The work in connection with the unit on the metric system is outlined carefully in the exercises of the Companion Book. The first exercise helps students understand the relationship between density and other ways of comparing substances. The exercises on pages 31 through 36 are designed to help the student learn the metric system by applying it to many situations with which he is already familiar.

Children always suggest many additional activities that they would like to do. Any one of the exercises in the Companion Book can be expanded and varied to meet the demands and the suggestions of any class.

YOUR SKIN (Pages 48–81)

Science Concepts:

Growth and change of an individual begin before birth.

There are three layers of skin.

Skin is composed of cells.
Differentiation of cells exists in the skin.
Glands are composed of cells.
Oil is produced by sebaceous glands.
Perspiration is produced by glands.
All parts of the body are composed of cells.
Activities necessary for life processes occur in each cell.
Cells have walls.
Each cell exchanges food and waste materials.
The body is continually producing new cells.
Papillae form characteristic fingerprints.
Food is carried by blood stream.
Skin contains nerve cells.
Skin cells produce many different things.
Hair contains pigment.
Growth and development require certain minerals.
Sweat glands eliminate waste.
Body temperature is affected by perspiration.
Bacteria cause fermentation.
Emotions affect blood vessels.
Stimuli produce changes within the nerves.
Sunlight causes change to occur within the skin.
Skin color is caused by pigment.
Sunlight destroys fungi and bacteria.
Ultra-violet radiations produce Vitamin D in the body.
Food needs vary with exercise.
Decomposition produces gases.
Micro-organisms may be transferred.
Skin disease is affected by diet.
Soap contains alkali and fat.
Grease is emulsified with soap and water.
Air contains micro-organisms.

Overview of the Unit

The unit, "Your Skin," is divided into five sections:

1. Where did your skin come from?
2. What is the skin?

3. Out of your skin.
4. In your skin.
5. You and your skin.

The unit is organized to first present the main scientific facts about the development and the characteristics of the skin. The rest of the unit is devoted to the application of these scientific facts to questions which are interesting and important to boys and girls who wish to understand how and why their bodies function as they do. One section tells how hair, fingernails, toenails, perspiration, oil, dandruff, wax, and callouses are developed. Their effect on the body and the health habits important in relation to them are suggested. Another section explains the functioning of the part of the nervous system which is found in the skin. Temperature, touch, and pain are explained. The last section of the unit makes application of the above information to the development of health habits that are important for boys and girls.

The main exercises in the Companion Book which are to be used with this unit again emphasize problem solving. The exercise on page 37 is similar to the exercise on page 9. It has been the plan of these Companion Books to present exercises which help develop certain skills at different times during the year so that frequent use in new situations will make the student apply the skills many different times. The exercise on page 39 is similar to the one on page 7. It requires a review of important ideas the student has learned. The exercise on page 7 helps to explain the use of science in a community. The exercise on page 39 helps to explain the use of science in explaining the human body. Each of the sentences to be completed is related to a problem which is stated for each individual child. For example: "Why does my hair grow?" The teacher should emphasize the fact that the three sentences can be written by each individual person to answer the question for himself. Children are provided with information to answer questions that are personally interesting to them.

The second part of the exercise on page 40 helps the student analyze and synthesize his information in relation to the problem. This is the same type of work that was suggested for the first

unit. The exercise on page 41 helps them practice the skills necessary to recognize similarities and differences.

The importance of the information which the children learn can be measured by the number of times they apply that information to health practices. Page 45 provides a chart on which the children may keep a record of their health habits in relation to the things they have studied in the unit. The exercise on page 46 is designed to help students state problems.

One of the activities of the first unit was to look through the pages and write down the question or the problem which could be answered with that information. The same technique is used again in this exercise. In addition the students are given the six criteria by which to judge a good problem.

The second exercise concerning safety and the use of equipment is on pages 46 through 48. The first safety exercise was headed with the question: "Is equipment safe with you?" Its purpose was to help make students conscious of their own safety habits. The second exercise, page 46, is titled "Responsibility for equipment." The teacher should make a point of each of these carefully worded titles. Each title emphasizes an important idea.

When the students understand the purposes of the unit and the exercises in the Companion Book they should be able to work by themselves. The teacher can devote his time to helping students individually.

Suggested Activity No. 1:

Visit an elementary school. Observe and describe the skin of the children. Visit a family in which there is a baby who is under a year old. Observe and describe its skin. Visit someone who is very old and describe his skin. Make a chart of the descriptions.

Suggested Activity No. 2:

Find as many advertisements about the hair, fingernails, toenails, perspiration, and dandruff as you can. List the idea which is emphasized in each one of these advertisements. What kinds of suggestions are made for the care of the skin?

Suggested Activity No. 3:

Keep a record of observations of the evidence you see that people need to take care of their skins. Put down on a piece of paper what you would suggest that each person do to improve his appearance.

SUMMER IN THE FOREST (Pages 82–107)

Science Concepts:

Humidity is a measure of moisture.
Friction produces heat.
Trees have three main parts: crown, trunk, root.
Leaves contain chlorophyll.
Leaves manufacture food from water, carbon dioxide, and minerals.
Oxidization of food produces energy.
Trees are composed of different kinds of cells.
Climatic conditions affect tree growth.
Various chemicals preserve wood.

The first part of the unit on forest fires is designed for individual study by the students. Teachers should present an overview lesson, help the students make their study guides, and then help them evaluate the work they have done.

Suggestions for the Overview Lesson

On a bulletin board place a silhouette of a parachute and a match. Place these questions on the bulletin board: "Why does the match make the parachute open? When does the match make the parachute open?" Obtain also pictures of a man, of a match, and of a tree. Make two plus (+) signs and one equal (=) sign. Ask a student to arrange these six items so that they will equal a parachute opening. The student should place them in the following order: Man + match + tree = parachute opening. Ask these questions: "When might this statement be true? What is the problem that is suggested by this bulletin board?" The student should state the following problem: "How can forest

fires be prevented?" In discussing the study guide to direct the study of this unit, the following questions should be suggested: "What causes forest fires? What kinds of forest fires are there? What is done to put out forest fires?"

The students should read pages 82 through 98 and list the information which will help to answer each of these questions. In addition to reading these pages they should also do the exercises in the Companion Book on pages 49 to 54. When the information has been collected the student should use the answers to the questions to form a generalization in answer to the main problem.

The exercises in this section of the Companion Book begin a series designed to help students collect information from different kinds of material. The exercise in this section teaches them how to collect material from a map. As soon as the problems have been answered, the students should do the exercise on page 55.

The second part of this unit presents material to explain the plant as a living organism. The exercises in the Companion Book are intended to extend and provide additional experience with this material. The last exercise, pages 62 through 66, gives additional help in working with problems. The students should check the work that they have done in their study guides to see if they have followed the nine steps suggested in the exercise.

Suggested Activity No. 1:

Ask the students to bring samples of twigs and branches and to locate the layers containing the xylem, the phloem, and the cambium.

Suggested Activity No. 2:

Suggest that some students bring tips of many different plants. Mount them on the bulletin board and with arrows indicate the growing point as shown on page 100 of the text. These plants may be house plants, bushes, trees, water plants, weeds, grasses, or any other kind available in the community.

Suggested Activity No. 3:

Ask a student to bring a cross section of a small tree so that the class may practice counting the annual rings.

Science Concepts:

Eating habits affect behavior.
Food must be changed physically and chemically for body use.
Digestive juices are produced by body organs.
Emotions affect digestion.
Body fatigue affects digestion.
Foods are composed of elements such as carbon, hydrogen, oxygen, and nitrogen.
There are different classes of foods.
Minerals are essential to growth and development.
Vitamins are essential to growth and development.
Plants produce vitamins.
The body changes food to energy.
Taste buds are sensitive to sweet, salt, bitter, and sour.
Gastric juices are composed of several substances.
Stimuli cause muscular reaction.
The body contains two systems for transporting food.
Food is absorbed into the transportation systems.
Some materials cannot be digested or absorbed.

The beginning of this unit stresses the effect of foods on behavior. It has been discovered with a number of classes of children in the junior high school that the memorizing of habits about eating balanced diets and other common topics is useless as effective understanding unless it is related to something that is important to a child of this age. At this time he is conscious of his behavior and he is looking forward to an adult type of behavior that will win him social approval. For these reasons behavior and food are stressed at the beginning of this unit. The exercise in the Companion Book on page 69 is designed to make students conscious of the kinds of things that they eat. A good beginning for this unit is to ask students to do this exercise and then to read what they have written to the rest of the class. This will also give the teacher an idea of the kinds of foods the children in the class are in the habit of eating. As a result of this exercise, the stimula-

tion is provided for the next one on page 70. This exercise should be done when they have read pages 108 to 114 in the text. The teacher should give some thought and time to the discussion of these pages since they set forth some of the most important ideas in relation to the eating habits of children.

Additional activities for the introduction of this unit might include a description of the foods that are eaten by people in other countries. A standard encyclopedia will provide the teacher or a student with this information.

The rest of the unit from pages 115 through 162 presents information about the digestive system in an organization suggested by a group of children. The questions in this section are those that are most important to children of this age. The teacher will notice that the questions are concerned with the processes of digestion, the parts of the digestive system, and some of the diseases that occur.

Pages 71–72, 76–77, and 81–83 of the Companion Book suggest some interesting experiments in the testing of foods.

Other exercises in the Companion Book continue the development of certain skills which were introduced earlier. On page 73 there is an exercise for getting information from a table, which is a continuation of the series which began with obtaining information from a map. On pages 74 and 75 is a very important lesson on the use of reading signals. Pages 78 and 79 list the eight steps of problem solving in relation to experiments. It would be well to have the students review the experiments which they have done and to make a record of them according to the eight steps that are listed here. The first testing exercise will help students learn science vocabulary; it is presented on pages 86 and 87. The words are the ones which have been used throughout the first units in the book.

Suggested Activity No. 1:

Ask students to bring a variety of foods which they eat, place them on a table, and classify them into carbohydrates, proteins and fats. Have them make signs which show the elements of which these foods are composed.

Suggested Activity No. 2:

Make a number of different slips on which are printed words of the different parts of the digestive system (see diagram, page 153, for a list of the parts). Ask a group of students to choose these slips and then arrange themselves in the right order according to the digestive system in the body. Ask each student to explain what his function is in the digestive system.

Suggested Activity No. 3:

Ask a nurse or parent who has a diabetic child to explain the kind of diet that the child must have.

Suggested Activity No. 4:

Have the students ask as many different people as possible what they believe is the best remedy for hiccoughs. Record the suggestions and then test the value of them by the information on page 148.

Suggested Activity No. 5:

Follow the same procedure as suggested in No. 4 for appendicitis.

Suggested Activity No. 6:

Collect as many ideas about the value of different kinds of food as you can. Students may suggest that celery is good for the nerves and fish is good for the brain. Ask the students to verify these statements by the material in the textbook.

Suggested Activity No. 7:

The same food does not taste the same to each person. Try this experiment. Bring to class packages of candy drops of some of the following flavors: lime, lemon, strawberry, cherry, peppermint, wintergreen, clove, raspberry, and orange. Ask the students to close their eyes and to eat one of each kind of candy. They should record the taste of each piece. When they have finished, make a chart on the blackboard so that they can record the answers. Compare the answers of the group to the candy samples which they

tested. Ask this question: "Why don't all people identify the same flavors?"

Suggested Activity No. 8:

Have the students demonstrate the correct way to help someone who is choking. Give them this experience: "A boy was eating a large bing cherry. It slipped down his throat before he could chew it. He was unable to speak. He pointed to his mouth and his aunt recognized that he was choking. She grabbed his two wrists and waved his arms up and down. She then turned him around, made him bend over, and hit him on the back. The cherry popped out of his mouth." Ask the children to form two groups and to discuss if this was a good thing to do. Have one member of each group report the conclusion to the entire class.

WEATHER AND FLIGHT (Pages 163–208)

Science Concepts:

Meteorology is the study of weather.
Weather is a condition of the atmosphere.
Atmosphere is a mixture of elements and compounds.
Atmosphere is held to the earth by gravity.
Atmospheric pressures change as the distance from the earth changes.
The atmosphere is composed of three layers: troposphere, ionosphere, and stratosphere.
Weather is affected by heat.
The sun radiates energy in all directions.
Radiant energy of the sun moves in waves.
The earth's distance from the sun is measured in miles.
Heat is produced by the motion of molecules.
Temperature is affected by altitude.
Weather conditions are caused by variations of temperature, pressure, and moisture.
The earth is inclined on its axis.
The earth rotates on its axis.
The structure of the earth's surface causes varying amounts of heat to be produced.

Air expands when it is heated.
The density of air decreases as temperature decreases.
Changing air temperature causes circulation.
The movement of the earth affects air masses.
Bodies of water affect air masses.
The earth's surface affects air masses.
Moisture exists in different forms.
Friction may produce static electricity.
The movement of air molecules may produce sound waves.
Negative and positive charges attract each other.
Air masses have different characteristics.
Liquids expand and contract with temperature changes.
Metals expand and contract with temperature changes.
Air has weight.

This unit represents material important in aviation education. A knowledge of the prediction, measurement, and causes of weather is essential to the understanding of aviation. The eighth-grade book of the How and Why Science Series presents material on airplanes, how they are constructed, why they are able to fly, and the instruments which are used by the pilot. That section is dependent upon the information in this unit of the seventh-grade book.

The introduction to this section is made in the Companion Book with the exercise on scientific thinking, page 88. Since this is designed to indicate the attitudes that students have, the teacher should explain the relationship between this exercise and the unit, "Weather and Flight." The first sentence on page 163 states that the safety of flight depends on a knowledge of the weather. Ask the children to discuss which one of the statements on page 88 of the Companion Book would be a reliable way to insure the safety of flight in relation to weather. It would be impossible to have scheduled transport flights if pilots made their conclusions about the weather the way that these people made their conclusions about flying discs. If, for instance, a pilot said, "I had a feeling in my bones there was going to be a storm," that would be a poor excuse and a poor substitute for a knowledge of the weather that he might have used. The teacher should make the point that people are

very willing to discard superstitions when their lives are in danger. No one is willing for a pilot to fly a plane by superstition. They want him to know the right thing to do since his knowledge may determine how long they will live. The teacher can also make the point that when one is riding in a car he feels safe because the company which made the car depended upon knowledge rather than upon superstition.

This unit represents the last one for the first semester of the school year. Many teachers and students like to present a parent program so the children may demonstrate the things they have learned during the semester. This unit provides an excellent opportunity for such a program and makes a good culminating activity for the students. The students should read pages 164 through 208 and do the exercises in the Companion Book, pages 90 through 106. When they have finished their reading and the exercises they should plan a program in the following manner: First, select a group of students to do experiments and demonstrations for parents which will show some of the important information that has been learned in this unit. Second, another group of students should make or collect pictures and diagrams which will illustrate important points that have been learned. These may be mounted on bulletin boards or upon white cardboard to be placed around the room. Another group of students should take the responsibility of being able to explain the questions which are asked in this section of the Companion Book. The program might be centered around this topic: "How Have We Learned Our Science?" Different committees might explain the following topics:

1. We have learned by reading.
2. We have learned by observing pictures and diagrams.
3. We have learned by observing and doing experiments and demonstrations.
4. We have learned by applying our information to many different kinds of situations.
5. We have learned by the problem solving method to recognize problems and to answer them.
6. We have learned to select facts to answer a question.
7. We have learned safety habits.

8. We have learned how to improve our reading.
9. These are the facts and principles we have learned.

ELECTRICITY (Pages 209–230)

Science Concepts:

Magnetism is an attraction between substances.
All magnets are surrounded by magnetic fields of force.
All magnetic fields around a magnet form curved lines of force.
An electric current passing through a wire produces magnetism.
Magnetism may be induced.
Electromagnets depend upon strength of current, turns of wire, and type of core.
Electrons flow from plus to minus.
Like poles repel and unlike attract.
Direct current moves in one direction.
Different materials offer different amounts of resistance to the flow of electrons.
Water power may be transformed to electrical energy.
Electric current is induced in a wire when it passes through a field of force.
Alternating current changes the direction of flow.
Electricity will travel through a vacuum.

The exploration of the community has included information about police stations, light in the home, the individuals in the community, plants in the community, and the atmosphere and weather of the community. The next unit presents additional physical principles concerning electricity and machines in the home and in the community. Pages 209 through 219 present the main facts and principles needed by the student who is to be able to explain, analyze, and predict how electricity is used in homes and in communities. It would be well for the teacher to identify the three key terms in the first pages of this unit. They are *magnetism, magnetic fields,* and *electro-magnetism.* In addition to these key terms there are four principles printed in italics that are

important to the understanding of the rest of the unit. With these main terms and these principles the student should be able to understand the material about motors on pages 215 through 218. The main purpose of this unit is to help students use their information to analyze, predict, and explain how different electrical machines in the home and in the community operate. The exercise on page 106 of the Companion Book is designed to give the teacher information concerning how well the student is able to apply one of the fundamental facts (magnetic poles which are alike repel one another and magnetic poles which are not alike attract each other) to machines that are shown in How and Why Explorations. Encourage the students to look through the part of the book they have studied and to select machines to list in the spaces provided on page 106.

The second exercise in the Companion Book suggests a new way for students to indicate the skills of problem solving which they have developed. Too often teachers require only one pattern of problem solving without emphasizing that there are many different ways of thinking about information. The exercise on page 107 encourages students to think of evidence which proves certain facts. The evidence is gained from the experiments which they have done in relation to this unit on electricity. Before the students do this exercise they should do the experiment suggested on pages 209 through 217. The next exercise on page 109 of the Companion Book identifies problems with experiments. These problems are identified with the reading that is done in the section, "Electricity for Cities." This exercise can be used as a directed reading activity to guide the students in their study of this section of the unit. Page 110 of the Companion Book is provided so that students may compare the actual number of hours electricity is used in their homes to the number of hours indicated on the chart.

The next exercise continues the development of the skills of gathering information. In this exercise students learn to get information from a graph. The teacher should, if possible, provide a number of different kinds of graphs so the students may do the same exercise using a variety of different materials. The last section of the unit, pages 225 through 230, may be studied by using page 114 of the Companion Book as a directed study guide. The

students are to select the ways in which these machines are similar and the ways in which they are different.

Suggested Activity No. 1:

There may be many electrical machines in the community or in the home that have not been described in this unit. Ask students to make a list of the machines they actually see which use electricity as a source of power. When the students report their lists the class should classify them as to the places where they are used.

Suggested Activity No. 2:

Ask the students to make a graph to indicate in what kinds of places the most electrical devices are used. They may make the same kind of graph for different rooms in the home.

Suggested Activity No. 3:

If your school is located near a city in which there is an office of an electric light company, ask one of the representatives of the company to bring a light meter to school and to talk about the amount of light and its relation to eyesight. One of the students may have a light meter he uses when he is taking pictures. Ask him to measure the light in different parts of the room. Ask the students to construct a map of the room which will show the differences in light in various parts of the room. The person who is using the light meter will start at one end of the room and walk to the other end. Each time the light meter changes significantly he should indicate the change to the group. A dot should be placed on the map of the room and a figure placed there to indicate the amount of light. If three trips are made each way of the room, it should be possible to plot the amount of light in each section of the room.

Suggested Activity No. 4:

Students may be able to report about trips to some of the famous dams in the United States. The teacher can write for material which will help explain the construction and the purpose of such dams as Norris Dam in Tennessee.

HOSPITALS AND HEALTH (Pages 231–242)

Science Concepts:

The first hospitals were organized about 1,500 years ago.

Plants and herbs may relieve the sick and sometimes cure them.

Some herbs used in early days are still important medicines.

Monks were often the doctors in early history.

The monks of the early days knew nothing about the body organs.

Early medical men did not know about micro-organisms.

Hospitals had been established 900 years before it was known that contagious diseases were connected with unsanitary conditions.

Early communities learned that disease could be carried by people.

Early doctors learned that people working in certain occupations developed certain diseases.

People in communities learned early that disease could be spread by food and other goods.

Man gradually found that there was a relation between clean water and amount of disease.

Many boys and girls know more about the body today than the wisest scientist of the 18th century knew.

The invention of the microscope enabled the scientist to make many important discoveries about health.

The development of anesthetics enabled surgeons to care for the sick and injured with greater safety and with lessened pain.

Man's constant search for truth has enabled him to make discoveries and increase his knowledge.

The unit on hospitals and health presents an entirely different viewpoint than is usually presented in science books for seventh-grade children. The teacher should read carefully the sentence on page 231—"Although it was an accident that placed the boy in the hospital it was not an accident that there was a hospital and

that there were doctors who knew what to do to save the boy's life." This is the theme of this unit. Many adults have learned to accept the achievements of science with little regard for the human effort that has made them possible. In the other units of this book the emphasis has been upon the application of science for the improvement of man and his community. This section is in the nature of applause for the scientists who through the centuries have struggled against prejudices, biased opinion, persecution, and ignorance to discover the information which we in this century apply.

The other interesting note about this section, as with many units in this book, is that the introductions and the incidents that are used are those that have actually happened to people who are, or have been, living. The purpose of doing this is to get pupils (and teachers) in the habit of recognizing the significance of everyday happenings in relation to the science facts and principles that are necessary if certain results are to occur. The exercises in the Companion Book are designed to help students select from the reading material those important points which answer the question: "How has science changed our activities and improved our living standards?" This again is another approach to the skills of problem solving. When children leave school it will not be usual for them to discover sources of information which specifically answer the questions they ask. For this reason it is wise to give them practice in school in "digging out" information to answer specific questions. The questions on pages 116 through 119 of the Companion Book will not be found in the unit on hospitals and health. The answers to these questions are not listed in any order in this unit. The students will have to relate what they read to the main ideas in these questions.

A suggestion for studying this unit is to have the students first read the story from the beginning to the end. They should look carefully at the pictures. They should read as much for enjoyment as for information. When they have completed the reading and have classified the questions they have jotted down, then they should do the exercises in the Companion Book on pages 116 through 119. The other exercise in connection with this unit con-

tinues the development of the skills in gathering information. This one emphasizes pictures as a source of information. The picture on page 236 is an excellent one to use for this type of activity. Many other pictures in the textbook or ones that the teacher brings can be used to give additional practice in using the steps suggested on page 120 of the Companion Book.

Suggested Activity No. 1:

Have students collect as many newspaper clippings as they can which indicate things that have happened to people from which they would not have recovered if hospitals and doctors had not been available.

Suggested Activity No. 2:

Ask a pharmacist to speak to the class about the common plants that are used at the present time to treat disease.

Suggested Activity No. 3:

Some of the students may be able to bring castor beans, sassafras, or other plants which are used for medicines. These may be posted on the bulletin board.

Suggested Activity No. 4:

Ask students to interview members in the community for suggestions of plants that they have heard are useful to cure certain illnesses or to relieve pain. It may be possible for them to obtain information from different sections of the country by writing to their friends or relatives.

Suggested Activity No. 5:

Some of the students may enjoy reading about William Harvey, Louis Pasteur, or other scientists who have been associated with the improvement of health.

Suggested Activity No. 6:

It may be possible for teachers, principals, or parents to recall conditions in the school building which were unsanitary and have been improved. A list of these might be made.

Suggested Activity No. 7:

Perhaps some parent will come to school and describe the schoolhouse or room where he went to school. Compare the sanitary facilities with the ones that are available in your school. A grandparent might also come.

PLANT REPRODUCTION (Pages 243–253)

Science Concepts:

There are two kinds of flowers, perfect and imperfect.
Some plants contain only male organs.
Some plants contain only female organs.
Plants are composed of various structures.
Structures of male and female plants differ.
Male plants produce pollen.
Female plants produce eggs.
Reduction division occurs in sperm and egg cells.
Sperm cells fertilize egg cells.
Most plants contain both male and female organs.

The unit on plant reproduction is one for which the teacher should prepare materials so that the students may have the experiences which are suggested in this unit. It is not necessary to have an angel-wing begonia in order to do the same things that these children have done. Other kinds of begonias will work as well, although the blossoms and seed pods are not so large. Since the begonia is so common in greenhouses, homes, and stores, it should not be difficult to obtain a plant which is either already in bloom or soon will be. These plants continue to bloom profusely with very little care. If it is possible for each child to obtain his own begonia plant, the plants can be used to decorate the window sills and improve the appearance of the room as well as for the purpose of the unit.

When the plants have developed seed pods, begin the story of this unit. Select students to be the characters in the story and to follow through the same things that the characters say and do on these pages. It is not necessary for the teacher to represent Mr. Chase, but special time should be given to the person who is to be

Mr. Chase so that he is thoroughly familiar with the material. It will be necessary for the teacher to organize the work so that the materials needed will be available. When the children have finished with this story they will probably discover that things did not happen exactly as in HOW AND WHY EXPLORATIONS. Have the children write their own story to relate what actually happened. Use pages 121, 122, and 123 of the Companion Book as a review or a test exercise. If the children are not able to do this by themselves, let them refer to the textbook to complete the exercise. The exercise in the Companion Book on pages 125–128 may be used as the pupils read the units in the text.

Suggested Activity No. 1:

Ask the students to list those diagrams which show things that can be seen without the aid of a microscope and those things which can be seen only with the aid of a microscope.

Suggested Activity No. 2:

Collect the pollen from many different kinds of plants and examine it with a hand lens or under a microscope.

Suggested Activity No. 3:

Obtain the flower of a tulip, a lily, or another flower of this kind and dissect it to discover how many of the parts can be seen.

Suggested Activity No. 4:

Find a plant, preferably outside, which has pollen on it and observe the plant for one hour. Make a list of the number of times something happens to remove the pollen from the plant.

FIRE FOR MAN
and
TEMPERATURE CONTROL IN THE HOME
(Pages 254–304)

Science Concepts:

Burning produces heat.
All fuels contain carbon.

Burning is the uniting of oxygen and carbon.
Burning causes a chemical change to take place.
Water is composed of hydrogen and oxygen.
Each fuel has a critical kindling point.
Electrical energy may be changed to heat.
The movement of molecules produces heat.
Electricity causes movement of molecules.
The amount of heat produced by electricity depends upon current and resistance.
Heat breaks down cell walls.
Heat causes chemical changes in food.
Pressure affects the boiling point of a liquid.
Some materials do not conduct heat.
Heat does not pass through a vacuum.
There are various ways of heating a home.
Heat is transferred by conduction.
Heat is transferred by convection.
Heat is transferred by radiation.
Water absorbs heat.
Water may radiate heat.
The evaporation of liquids depends upon temperature and humidity.
Molecular motion varies in liquids and solids.
Evaporating water absorbs heat.
Metals expand at different rates.

The units, "Fire for Man" and "Temperature Control in the Home," are two that are so closely related that they should be considered as one unit. The first section, "Fuels and Heat," continues the concept of elements and their relation to each other that was begun with the unit, "Atoms for Energy." In addition to these concepts the relationship between energy and materials is developed. The first concept in the unit, "Atoms for Energy," developed the idea that some kinds of energy are a result of changes which take place within atoms. The present unit develops the idea that other forms of energy are a result of atoms combining and molecules changing chemically. The first exercise in the Companion Book, on page 124, can be used as an introduction to

this unit to help develop the idea of changes which occur as elements combine with each other.

It has been some time since the children worked by themselves making a study guide and following it to answer the main problems which they have stated. With the experiences which they have had it should be possible for them to do a great deal of this by themselves.

Ask the students to read the two units, "Fire for Man" and "Temperature Control in the Home." As they read through these units rapidly, they should list ideas for pictures, diagrams, experiments, or stories that would be good to use if they were to introduce this material to another class. Recall for them the kinds of things that were done to introduce the unit, "Summer in the Forest." Ask them to devise the same kinds of activities. When their plans are made and the materials gathered, give each person an opportunity to show how he would introduce the unit to another class. When this is done, ask the students to make a study guide to direct their work for these two units. Recall for them that a good study guide includes the statement of the main problem, the statements of sub-problems, the activities necessary to solve these problems, and plans for analyzing, synthesizing, and making the conclusions to the problems. Work with the students so that the study guides which they develop are approved by you before they begin to work. Remind the students that their study guides should include the exercises in the Companion Book. These exercises are on pages 128 through 134. When the students have finished their study guides, ask each member to read the problem he has selected. Judge his problem by the criteria listed in the Companion Book. Each child should also read his answer to the problem. Judge these answers by the criteria in the Companion Book.

Suggested Activity No. 1:

Write to the Universal Match Corporation in St. Louis and ask them for reprints of their pictures which portray the history of fire. Ask the students to indicate in each picture the source of carbon, the oxygen, where they combine, the kind of heat that is produced, and the effect of that heat.

Suggested Activity No. 2:

The children may enjoy making a diagram of the furnace or stove which is used in their own homes to provide the heat.

Suggested Activity No. 3:

From catalogs and advertisements they can select pictures of all the different types of devices which are used to provide heat. They can write the similarities or the differences of these devices.

Suggested Activity No. 4:

Ask the students to make maps which show the sources from which coal is obtained for their community. Perhaps it would be possible for them to discover how much coal is brought into the community by different companies and how much is used each year by people in the community. It might be possible for them to get this information for natural gas if it is used for heating purposes.

Suggested Activity No. 5:

If the information is available, students may make a flow-diagram of the materials used for heating purposes in the community. A flow-diagram of this kind should show the routes and the devices by which fuel is brought into the community.

YOUR TEETH (Pages 305–321)

Science Concepts:

Some teeth are permanent.
Baby teeth are the first to develop.
Teeth are composed of several parts.
Diet affects the teeth.
Decay may be caused by bacteria.
Dentrifices vary in health value.
Various drugs affect the nervous system.

A unit on teeth is always a difficult unit for students to study with any degree of interest, since they have been talking and studying health habits in relation to teeth ever since they were in

the elementary school. A recent study of children's interest in health indicated that one of the most boring activities to them is the drawing of a tooth. The common complaint was that they had been made to draw teeth from the first grade through high school. It is the aim of the authors in this section to present information about teeth in relation to questions which children have often asked. The first one, "Why do first teeth fall out?" is a very common question which is seldom answered for children. The second question, "How many teeth can you have?" is another one which many students have been very serious in asking. The last section of this unit, "The Work of the Dentist," has been included to help change the attitudes of students in relation to their visits to the dentist. Filling of cavities, extractions of teeth, the giving of anesthetics, the straightening of teeth, and the making of false teeth are fascinating to students, but too few of them ever have an opportunity to discuss or talk about these things except in a dentist's chair. The exercises in the Companion Book on pages 135–139 continue the development of the skills of gathering information.

One of the most healthful activities which can be initiated by the teacher is the discussion and the reading of this section with the purpose of allowing students to contribute their own experiences, and to talk freely of the way they feel and act at the dentist's. It is comforting to students to know that other students have the same fears that they do. Many times the opinions of a group and the sympathy of other people can change attitudes more quickly than other methods. Students who become so interested in what is actually happening to their teeth are less likely to be afraid to have their teeth corrected. The work of the dentist emphasizes the need for applying the information in the first section of the unit. Another reason for including the topic on straightening teeth is to help students understand one another and not to feel embarrassed if they happen to be having their teeth straightened. Those students who are able to accept the fact that discomfort may mean improved appearance, and who can accept the fact that other people are interested about the how's and why's of having teeth straightened, may overcome their resentment at having to have this done. As the teacher and the student work together in reading, studying, and discussing the material in this unit, informal

activity may provide many opportunities for helping students develop the correct attitude. It is impossible to accomplish with students changes in behavior which are offset by poor habits developed through many years of incorrect thinking and practice by teachers and adults. Just to find out how they feel about these things may indicate some ideas that might be given to parents which would help them develop the correct habits with children.

Suggested Activity No. 1:

Perhaps one of the dentists in the community would bring to school some of the materials that he uses in his office and explain them to the students.

Suggested Activity No. 2:

A dentist may be willing to allow the class to visit his office and ask questions about the things that they see there.

Suggested Activity No. 3:

A group of students may plan to interview a dentist and ask if it would be possible to collect either pictures or teeth that have decayed to show the parts and the places where decay has started. Some dentists have available photographs or X-rays that they are willing to loan if the teacher has the equipment to show them to students.

ENGINES ON TRACKS (Pages 322–343)

Science Concepts:

The pressure of gases increases with heat.
Expanding gases produce a force.
The amount of friction depends upon surface and type of materials.
Vibrating air molecules produce sound waves.
Chemical energy may be changed to electrical energy.
Air offers resistance to moving objects.
Internal-combustion engines burn fuel inside the engine cylinders.
There are various kinds of internal-combustion engines.

Increasing the pressure of a gas increases the temperature.
Increasing the temperature of a gas increases the pressure.
Objects in motion tend to remain in motion.

The unit, "Engines on Tracks," explains how steam engines, streamlined trains, diesel engines, and electric engines operate. Many of the concepts in this section represent applications of facts and principles which have been learned in previous sections. Most important new concepts are those involved in the operation of the internal-combustion engine. The exercises in the Companion Book on pages 140 through 146 help develop the main ideas in the book. The teacher and the student should work together to list the scientific facts in this unit in relation to the following questions:

1. Why do the wheels move?
2. Why do whistles blow?
3. Why do bells ring?
4. Why is it possible to have electric lights on trains?
5. How does the engineer control the train?
6. How are water and fuel used?
7. How is the train stopped?
8. How are the cars fastened together?

Discuss with the students each one of the pictures and diagrams on pages 322 through 343. Ask the students to explain why these diagrams have been placed on these pages. The teacher should plan to use the exercises in the Companion Book in ways in which they will be most useful as the students list the scientific facts in relation to the questions above. If the teacher wishes to use these exercises as a review of the unit, they may be done when the rest of the work has been completed.

Suggested Activity No. 1:

If one of the students has an electric train or can borrow one, ask him to bring it to school and to tell as much as he can about it. When he has finished, have the students read the material on pages 322 to 342. Ask them to use this information to write a description of the train which has been demonstrated. Ask them also to de-

scribe what would have to be done to change the electric train into a steam train or a diesel engine.

Suggested Activity No. 2:

It may be possible for them to make a diagram which will show how certain forms of energy are changed into mechanical energy.

Suggested Activity No. 3:

Visit a garage, a used-car lot, or other places where it would be possible for the students to see the cylinders, the pistons, and the valves used in a combustion engine.

Suggested Activity No. 4:

Students may make a map of the community showing the routes and the devices which are used for transportation. They might indicate by symbols on the map the scientific facts which have been discovered that make these different transportation systems possible. A list of scientific facts and principles should be placed at the bottom of the map.

WATER ON THE LAND (Pages 344–370)

Science Concepts:

Warm air expands.
Expanding gas becomes cooler.
The water cycle is composed of evaporation, transportation, condensation, and precipitation.
Temperature determines the state of moisture.
An organism is a living thing.
All life requires moisture.
Environment is partly determined by amount of water.
Humus is composed of organic material.
Soil is composed of many substances.
There are many different types of soil.
Water changes the earth's surface.

The material in this unit continues the information begun in the unit on weather and flight in which the main ideas concerning

atmosphere and weather were explained. The construction of this unit is entirely different from the other units in the book. It aims at making this point: Each community rests upon a physical basis. This unit stresses that water is essential to life and it attempts to make students conscious of the fact that the amount of water available determines the amount and the kind of living organisms within a community. The letter which the students have written at the beginning of this unit suggests the emphasis that should be placed by the teacher while the students are studying. The improvement of communities by the application of scientific evidence is one of the goals of science in general education. Many students believe that communities never change. It is the duty of the teacher to impress upon them the great amount of change which is occurring constantly as they live in the community. The water cycle has been chosen as the first example of constant change.

The pictures on pages 346 and 347 emphasize that this unit is about the community. This particular unit should be introduced by the teacher through a discussion of the diagrams and the pictures on these pages. The educational significance of these pictures escapes all but the careful observer. The first picture should be studied in reference to this question: "What changes do you believe are occurring in this community at the present time?" Second: "What are the evidences that man is a part of this community?" The two pictures following on page 349 show a community of which man is not a part. Compare this community with the one on page 346. What are the similarities and what are the differences? The most apparent similarity is the evidence that water is available in each one of the communities. The greatest difference is that in the one the water cycle is affected by the things that men have constructed and brought into the community. On page 350 the water cycle is again shown in relation to a farm, and on page 351 the idea of what happens to water as a result of the water cycle is shown in the diagram of the plug of the earth. The beginning of the idea of the water-saturated zone is in this diagram. Compare this diagram with the one on pages 358 and 359. See if the children can relate similar parts of these two diagrams. You will notice the diagram following, on page 361, is again a picture of a natural community showing the water-saturated

zone. On page 358 there is a diagram of a community affected by man. On page 365 the drainage system of a community is shown. The last four pictures, pages 368 and 369, should be used as a discussion of the effect of water upon a community. With this introduction and discussion children should be ready for a new kind of problem: "How does the information in this unit compare with the information about our own community?"

It should be possible for the children to identify or discover kinds of soil in the community, the number of people, an estimate of the number of trees, the size of the farms, the number of wells, the lakes, and other features which are mentioned in this unit. When he has all the information to answer this problem, allow him to use the evidence to answer this problem: "Are the changes which are taking place in the community in relation to the water supply constructive changes or destructive changes?" "Why are these changes taking place?" The exercises in the Companion Book will help the student understand these ideas about his own community.

SCIENTISTS EXPLAIN ROCKS (Pages 371–386)

Science Concepts:

Geology is the study of the earth.
Forms of life have changed.
The earth's surface is changing.
Heat changes the form of rocks.
Pressure changes the form of rocks.
Male and female bone structures are different.
Archaeologists reconstruct the story of man on the earth.

One of the main purposes of this unit is to help students understand the sources of the rocks which they find in their communities, the importance of some of them, and a method by which they can identify the rocks which they have. The exercises in the Companion Book, pages 151 through 155, teach them how to use a key in order to describe the rocks they find in their communities. Have them list the pictures which are used to illustrate this unit of work. On the left side of the paper write the page numbers on which the

pictures appear. After each page number write a title for the picture which is brief but explanatory. Under the title of the picture write the best scientific facts which help explain the picture. Do the same thing for each one of the pictures in the unit.

Suggested Activity No. 1:

Have the children make an exhibit of the rocks which they have found and identified. Mount the rocks on small pieces of wood and write on a card a description of the rock and indicate how it was formed.

Suggested Activity No. 2:

If there are students who have rock collections in which there are rocks from other communities, ask them to bring them and show them to the class.

Suggested Activity No. 3:

Ask the students to plan a permanent shelf for a rock collection. Ask them to decide by what standards they will select the rocks to go in this permanent collection. Some suggestions are these:

1. The rocks should help explain the community in which the students live.
2. It may be an unusual rock from some other community.
3. It may be a rock which is used in an industrial process for products which are used in the construction of buildings in the community.

Suggested Activity No. 4:

Ask the students to collect samples of materials that are used instead of natural rock in the construction of buildings in the community. These may be cinder blocks, bricks, or other similar kinds of materials. If there is a store which sells these, ask a representative to explain how they are made and the characteristics which make them desirable for building construction.

Suggested Activity No. 5:

If there is a place where rock layers or soil layers may be observed, go on a field trip to examine them. Excavations for build-

ings, railroad, or highway cuts and banks of streams often show these layers.

THE CLUB EXPLORES AN ANCIENT CITY
(Pages 387–404)

Science Concepts:

Scientists have discovered that the American continent was inhabited by man before the American Indian lived here.

Archaeologists explore and gather evidence which tells us about life long ago.

Scientists have discovered that some early peoples had community burial grounds.

Scientists have discovered that some of the customs of early man, such as ceremonial fires, have preserved the skeletons of early animals.

Scientists can tell the average height of people by examining their skeletons.

Scientists have discovered that the occupations of the early people are often learned by the tools and materials buried with them.

Scientists are able to tell if the early tribes traveled by comparing the materials they used to the places in the country where it is naturally found.

Scientists are often able to reconstruct the buildings the ancient people lived in.

One of the oldest human bones discovered was found in Java.

Bones of men who lived centuries ago have been found at Folsom, New Mexico; in Nebraska, Europe, China, and Mexico.

Some scientists think the ancestors of early American people came from Asia.

The first inhabitants to live in America are believed to have arrived here by chance wandering.

Scientists believe the early tribes practiced some type of religion.

This unit is one which presents information that is not ordinarily included in junior high school books. The story has always been fascinating to children because it is something that exists and can be seen, and to which they may travel if they happen to take a vacation in this section of the country. The interest in science should be developed so that students enjoy watching for opportunities to take advantage of discoveries of the kind mentioned in this story. The presentation of this unit should be done as a group activity, perhaps as the last one of the school year, in which the students and the teacher read and discuss and enjoy in an informal way the story which is presented on these pages. It may be possible that in the section of the country in which you teach there are similar kinds of places which students could visit on the last day of school or about which they could write a story similar to the one which is here. Since throughout this book it has been emphasized that explorations in science need not be in foreign lands, but can take place in the school, the home, the community, and numerous other places, a final activity for the science class might be an exploration trip which is planned by a group of students as a surprise for the rest of the class. It might be a trip around the school or the community where certain facts and principles of science are in evidence. Have committees select the different units in the book and arrange the trip so that the main scientific facts of each unit are reviewed. The exercises on pages 156–158 of the Companion Book may be used while the pupils read pages 387–404 of the text.

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The good science teacher provides at least one magazine for his science students, if such magazines are not available in a school library. Some teachers prefer to subscribe to different ones different years. The best way to decide which magazine is most useful to yourself and your students is to order one copy of several and examine each one before placing the order for the year.

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Bausch and Lomb Optical Co., Rochester, New York.

Biological Supply Company, 1176 Mount Hope Ave., Rochester, New York.

Breeding and Laboratory Institute, 567 Third Avenue, New York City.

Central Scientific Company, 460 East Ohio Street, Chicago, Illinois.

Chicago Apparatus Company, 1735–1743 North Ashland Ave., Chicago, Illinois.

Clay-Adams Company, 117–119 East 24th Street, New York City.

Denoyer-Geppert Company, 5235 Ravenwood Avenue, Chicago, Illinois.

Fisher Scientific Company 709–717 Forbes Street, Pittsburgh, Pa.

General Biological Supply House, 761–763 E. 69th Place, Chicago, Illinois.

Marine Biological Supply Company, 329–331 Second Street, Ann Arbor, Michigan.

McKnight and McKnight Supply Company, 123 North Street, Normal, Illinois.

Spencer Lens Company, Buffalo, New York; 45 Second Street, San Francisco, California; 33 West 42nd St., New York, New York.

Standard Scientific Supply Corporation, 34–38 West 4th Street, New York, N. Y.

Ward: Charles H. Ward, Inc., 5–7 Prospect Street, Rochester, New York.

Welch: W. M. Welch Scientific Company, 460 East Ohio St., Chicago, Illinois.

Zeiss: Carl Zeiss, Inc., 728 South Hill St., Los Angeles, California.

SOURCES OF BULLETINS AND PAMPHLETS

American Child Health Association, 450 Seventh Ave., New York City.

American Forestry Association, 1727 K. St., N. W., Washington, D. C.

American Medical Association, 535 Dearborn Street, Chicago, Illinois.

American Museum of Natural History, Columbus Ave. and 77th St., New York City.

American Nature Association, 1214—16th St., N. W., Washington, D. C.

American Public Health Association, 450—7th Ave., New York.

American Red Cross, Washington, D. C.

American Tree Association, 1214 Sixteenth St., N. W. Washington, D. C.

Bauer and Black, 2500 South Dearborn St., Chicago, Illinois.

Borden: The Borden Company, 350 Madison Ave., New York City.

California Fruit Growers Exchange, Box 530 Station C., Los Angeles, California.

California and Hawaiian Sugar Refining Corporation, Ltd., 215 Market St., San Francisco, California.

Chicago Apparatus Company, 1735 North Ashland Ave., Chicago, Illinois.

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Eastman Kodak Company, 255 State St., Rochester, New York.

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General Biological Supply House, 761–763 East 69th Place, Chicago, Illinois.

General Electric Company, Department 166, Nela Park, Cleveland, Ohio.

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Heinz: H. J. Heinz Company, 1062 Main St., Pittsburgh, Pennsylvania.

Hershey Chocolate Company, Hershey, Pennsylvania.

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Johnson and Johnson, New Brunswick, New Jersey.

Metropolitan Life Insurance Company, One Madison Square, New York City or 600 Stockston St., San Francisco, California.

National Dairy Council, 910 South Michigan Ave., Chicago, Illinois.

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American Museum of Natural History, 77th St. and Central Park West, New York City.

Audubon: National Association of Audubon Societies, 1974 Broadway, New York City.

Chicago Apparatus Company, 1735–1743 North Ashland Ave., Chicago, Illinois.

Conrad Slide and Projection Company, 510 Twenty-Second Ave., East, Superior, Wisconsin.

Denoyer-Geppert Company, 5235–5257 Ravenwood Ave., Chicago, Illinois.

General Biological Supply Company, 761 East 69th Place, Chicago, Illinois.

Keystone View Company, Meadville, Pennsylvania.

New York Biological Supply Company, 34 Union Square, New York City.

Welch: W. M. Welch Scientific Company, 1516 Orleans St., Chicago, Illinois.

SOURCES OF MOTION PICTURES

Akin and Bagshaw Company, Inc., 1425 Williams Street, Denver, Colorado.

American Social Hygiene Association, 370 Fifth Ave., New York City.

Bray Productions, Inc., 729 Seventh Ave., New York City.

Eastman Teaching Films, 355 State Street, Rochester, New York.

Educational: The Educational Screen, Inc., 64 East Lake Street, Chicago, Illinois.

General Electric Company, 1 River Road, Schenectady, New York.

Metropolitan Life Insurance Company, 1 Madison Square, New York City.

Society for Visual Education, Inc., 327 So. LaSalle St., Chicago, Illinois.

SOURCES OF PROJECTION EQUIPMENT

Ampro Corporation, 6058 Sunset Blvd., Hollywood, California.

Bausch and Lomb Optical Company, 635 St. Paul St., Rochester, New York.

Bell and Howell Company, 710 North La Brea Ave., Hollywood, California.

Eastman Kodak Company, 355 State St., Rochester, New York.

Holmes Projector Company, 1811 Orchard St., Chicago, Illinois.

Spencer Lens Company, 45 Second St., San Francisco, California.

Western Electric, Electrical Research Products Company, 250 West 57th St., New York City.

SOURCES OF STILL PICTURES AND CHARTS

American Child Health Association, 450 Seventh Ave., New York City.

American Forestry Association, 380 Jelliff Ave., Newark, New Jersey.

American Museum of Natural History, 77th St. and Central Park West, New York City.

American Public Health Association, 450 Fifth Ave., New York City.

American Red Cross, Washington, D. C.

Armour and Company, Chicago, Illinois.

Audubon: National Association of Audubon Societies, 1974 Broadway, New York City.

Church, Dwight & Company, 27 Cedar St., New York City.

Keystone View Company, Meadville, Pennsylvania.

Metropolitan Life Insurance Co., One Madison Ave., New York City.

National Fire Protection Association, 40 Central St., Boston, Mass.

National Geographic Society, Sixteenth and M. Streets Northwest, Washington, D. C.

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Nystrom: A. J. Nystrom & Company, 2249 Calument Ave., Chicago, Illinois.

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A KEY TO THE COMPANION BOOK

p. 1—*Science in the Community*

1. *a.* So that it can explain why things happen in the community.
   b. So that it can explain how things happen in the community.
   c. So that it can explain the results of things happening in the community.
2. They could learn scientific facts which help solve crimes, and they could learn about one place in the community which uses scientific facts in its work.
3. Individual answers.

p. 2—*The Fingerprints of Your Class*

1. No.
2. Each fingerprint is different. The sex of the person has nothing to do with the differences.
3. *a.* ridges *b.* sensitive *c.* oily *d.* depressions *e.* skin

p. 3—*The Fingerprints of Your Class* (continued)

4. They are covered with skin which is in ridges and depressions. They are oily. I can feel objects because my fingertips are sensitive.

The Toeprints of Your Class

1. Check *b* and *e.*
2. *a.* Each has ridges.
   b. Each has depressions.
   c. Neither one can be changed.

d. Each one is made of skin.
e. Each is different on each person.
f. They are sensitive.
g. They are oily.

p. 4—*Scientists and the Police*

1. *a.* They have discovered that people have different fingerprints.
   b. They have classified information about fingerprints.
   c. They have discovered a method to identify people by their fingerprints.
   d. They have discovered that fingerprints cannot be changed.
   e. They have improved methods for identification.
2. *a.* They have fingerprinted millions of people.
   b. They have maintained records.
   c. They have found fingerprints at the scenes of crimes.
   d. They have photographed fingerprints.
   e. They have cooperated with the F.B.I.
3. *a.* It has made possible the identification of enemy agents during war.
   b. It has made possible the identification of criminals during peace time.

p. 5—*Using Scientific Information*

1. Check *g.*
2. *a.* They made fingerprints.
   b. They burned skin on their fingertips.
   c. They made fingerprints when the tips had healed.
   d. They compared the two sets of fingerprints.
   e. They repeated the experiment.
3. Their fingerprints were identical.
4. Their fingerprints were still identical.
5. Check *a*, *f*, and *g*.

p. 6—*Using Scientific Information* (continued)

6. *a.* Toeprints are easier to make.

b. Fingertips are smaller than the soles of feet.
c. The babies might get ink in their mouths if fingertips were used.

p. 7—*Scientific Facts and Crime*

1. *a.* identify
   b. change
   c. classified
   d. recorded
   e. the scene of the crime
   f. same
   g. saved
   h. found
   i. an identifying kind of blood type
   j. identify
   k. protect
   l. guilt . . . innocence
   m. right
   n. skin . . . blood
   o. different
   p. different
   q. different
   r. different

p. 8—*Scientific Facts and Crime* (continued)

2. Place an S before *a, b, c, d, e, f, g, h, i, j, k, l, m.*
3. Place a D before *n, o, p, q, r.*
4. *a.* Fingerprints and blood can help solve crimes because they can be removed from the scene of the crime, recorded, saved, and used to identify criminals.
   b. Fingerprints and blood types are characteristics of the skin and blood of a person which have been discovered to be characteristics which do not change.
   c. Fingerprints and blood types help identify innocent people and criminals because methods have been discovered that make it possible for the police to use these facts in solving crimes and protecting and helping members of the community.
   d. Individual answers.

p. 9—*How Are Problems Selected?*

1. Place a circle around *g.*
2. Place a circle around *g.*
3. *a.* Underline *chalk.*
   b. Draw a circle around (7) *chalk and light.*

p. 10—*How Are Problems Selected?* (continued)

3. *c.* Why can you see light in the tube when chalk is blown into it?
   d. Underline *water.*
   e. Draw a circle around (1) *water and air.*
   f. (1) Which is denser, water or air?
   (2) How do the different densities of substances affect what you see?
   (3) (2) above.
   (4) You have to use your facts to explain what you see and you have to think in order to solve the problem. You don't have to explain anything in (1).

Is Equipment Safe with You?

For page 17

1. *a.* tube
   b. flashlight
   c. chalk
   d. books
   e. wall

For page 18

a. pencil
b. glass
c. water

p. 11—*Is Equipment Safe with You?* (continued)

2. *For page 17:* *a.* direct light
   b. make light
   c. reflect light
   d. raise tube
   e. reflect light
   For page 18: *a.* show effect of water
   b. hold water
   c. compare pencil in water and in air
3. *For page 17:* draw a circle around *b.*
4. *For page 17:* place a check before *a* and *b.*
   For page 18: place a check before *a* and *b.*
5. *For page 17:* place a circle around *c, chalk.*
   For page 18: place a circle around *a, pencil; b, glass.*
7. Individual answers.

p. 12—*Reflected Light and Diffused Light*

1. Diffused light is reflected from many surfaces.
2. *a.* chalk dust and wall *b.* tube *c.* scattered
3. Picture 1: Place an X on fog near headlight.
   Picture 2: Place an X on roof or coat or foliage or ground.
   Picture 3: Place an X on seat of chair or clouds of dust.
   Picture 4: Place an X on coal which is hit by light.

p. 13—*Reflected Light and Diffused Light* (continued)

4. Picture 1: X at left; arrow to rooftop, side wall.
   Picture 2: X's at left; arrows to building, foliage, man's coat.
   Picture 3: X at left; arrow to mirror.
   Picture 4: X on lamp; arrows to foliage, tabletop.
   Picture 5: X on window; arrow to bowl.
   Picture 6: X at left; arrow to picture.
5. Objects with smooth surfaces do not reflect light in all directions.

p. 14—*Reflected Light and Diffused Light* (continued)

6. Individual answers.

p. 15—*Reflected Light and Diffused Light* (continued)

Before *a:* 2, 4, 6
b: 2, 4, 6
c: 2, 4, 6
d: 2, 4, 6
e: 2, 4, 6

Before *f:* 1, 3, 5, 7
g: 2, 4, 5
h: 5, 6
i: 3, 5, 7
j: 1, 3, 5, 7

Refraction and Density

1. *a.* It helps to compare substances.
   b. Weights of equal volumes.
2. Left-hand picture: write *water.*
   Right-hand picture: write *mercury.*

p. 16—*Refraction and Density* (continued)

3. *a.* They have the same volume.
   b. They are of different densities.

4. Circle *a*, *b*, *c*, *d*, *g*, *h*.
   Draw a line through *e*, *f*, *i*, *j*.
5. *a.* bending
   b. The density of objects causes refraction of light.
   c. transparent, translucent
6. Individual answers.

p. 17—*Refraction and Density* (continued)

7. *a.* Place MD on glass, pencil, pan, penny.
   b. Place LD on air in glass, air in pan.
   c. Place an Re on pencil, pan, penny.
   d. Place an Rf on water in glass, water in pan.
   e. Place an O on pencil, pan, penny.
   f. Place a Tr on glass.
   g. Nothing translucent.

p. 18—*Refraction and Density* (continued)

8. Schoolroom: Place MD on desk standards.
   Place LD on air in room.
   Place Re on desk tops, flowers, cabinet between bookcases, pictures above bookcases, ceiling lights.
   Place Rf on water in bowl, window glass.
   Place O on desk, blotter, books, etc.
   Place Tr on window glass.
   Place Ts on light shades.

   Living room: Place MD on bricks of fireplace, bridge lamp standard.
   Place LD on air in room.
   Place Re on mirror and figurine over fireplace, lampshades, tabletops, davenport, window drapes.
   Place Rf on lampshades, window glass.
   Place O on chairs, tables, lamp bases, bricks of fireplace.
   Place Tr on picture, window glass.
   Place Ts on lampshades.

p. 19—*Color*

1. *a.* Individual answers.
   b. it reflects light waves of the length our eyes see as green.
2. *a.* Individual answers.
   b. it reflects light waves of the length our eyes see as red.
3. *a.* Individual answers.
   b. it reflects light waves of the length our eyes see as orange.
4. *a.* Individual answers.
   b. it reflects all lengths of waves of light.
5. *a.* Individual answers.
   b. it reflects none of the waves of light.

Experimenting with Color

1.	*a.* black	*b.* black	*c.* black
2.	*a.* red	*b.* purple or violet	*c.* orange
3.	*a.* yellow	*b.* orange	*c.* green
4.	*a.* blue	*b.* purple or violet	*c.* green

5. The yellow and blue light waves are reflected to the eye.
6. The red and yellow light waves are reflected to the eye.
7. The red and blue waves are reflected to the eye.

p. 20—*Reflections*

On flat surfaces, such as 1, 4, 5, and 6, image appears much as it does in a mirror; on curved surfaces such as 2 and 3, the image is distorted.

p. 21—*An Experiment with Reflections*

1. Individual drawings.
2. Individual answers.
3. Individual answers.

p. 22—*Making a Mirror*

5. *a.* It spreads out.
   b. Mercury is an element.
   c. No.

d. The mercury on the tinfoil stuck to the glass and made a coating.

e. The mirror reflects rays of light that strike it. Reflected rays strike your eyes and you see your image.

f. The pool reflects rays of light that strike it. Reflected rays strike your eyes and you see your image.

p. 23—*Flashlights*

Place 3 before *a*.		Place 1, 2	before *f*.
3 before *b*.		1, 2, 3	before *h*.
4 before *c*.		1, 2, 4	before *i*.
4 before *d*.		3	before *j*.
4 before *e*.		4	before *k*.

p. 25—*Telescopes*

1. *a, b.* A refracting telescope has only lenses.
   The reflecting telescope makes use of mirrors, the only lenses being the two in the eyepiece at the left of the diagram.

   c. In each case, the light enters at the top of the diagram, and moves toward the eye. The eyepiece in the refracting telescope is at the bottom of the diagram.
2. The mirror reflects the rays of light that strike it.
3. Circle: *mirror*, *reflects*, and *light*.
4. See answers to 1 above.
5. Words should be *star* or *planet*.
6. No reflection in refracting telescope. There should be X's on the three mirrors in the reflecting telescope.
7. O's should be at all points of refraction in first diagram, and on the lenses in the second.
8. Refracting telescope contains lenses which refract light; a reflecting telescope contains lenses which refract light and mirrors which reflect light.

Using an Index

1. lens   2. p. 411
3. microscope, refraction, concave, convex, focus, high-power, low-power

4. pp. 25–27
5. In cameras to take pictures; in microscopes to enlarge objects; in telescopes to make distant objects seem larger and nearer.

p. 26—*Energy and Elements*

1. Circle *a*, *b*, *d*.
2. light energy . . . . elements

p. 27—*Scientists' Descriptions*

1. *a*. Write *water* and *oxygen* under picture #1.
   b. Write *oxygen* and *carbon dioxide* under picture #2.
   c. Write *oxygen* under picture #3.
2. *a*. hydrogen . . . oxygen
   b. oxygen
   c. carbon . . . oxygen
   d. hydrogen . . . oxygen

p. 28—*Scientists' Descriptions* (continued)

   e. oxygen
   f. carbon . . . oxygen
   g. two
   h. one
   i. two
   j. hydrogen . . . oxygen
   k. oxygen . . . carbon
3. In each diagram the protons and the nucleus are at the center; the electrons are moving in orbits around the nucleus. The protons are positive; the electrons are negative.
4. No one has seen atoms, and scientists have different ideas of what they look like.

p. 29—*A Review*

A. E before 2, 6, 21, 22, 25, 34, 37.
   After number: Hg before *mercury*
   Pb before *lead*
   Ag before *silver*

C before *carbon*
W before *tungsten*
Fe before *iron*
H before *hydrogen*

p. 30—*A Review* (continued)

B. 1. Write *number 1* after light, heat, proton, electron, electricity, ultra-violet, energy.
2. Write *number 2* after skin, mercury, blood, plasma, red blood cells, lead, Anti B, lens, silver chloride, metallic silver, slate, hypo, china, element, molecule, silver, carbon, smoke, tungsten, chalk, stone, iron, paper, hydrogen, compound.
3. Write *number 3* after spectrum, incandescent, fluorescence, density, translucent, transparent, color, nucleus.
4. All words have numbers after them.

p. 31—*Comparing Substances*

1. *a.* volumes . . . weights
   b. substances . . . weights
2. *a.* volume   *b.* weights
3. *a.* length   *b.* capacity   *c.* weight
4. Age 9: 49 inches; 1.2446 or 1.24 meters
   " 10: 51 inches; 1.2954 or 1.30 meters
   " 11: 53 inches; 1.3462 or 1.35 meters
   " 12: 55 inches; 1.3970 or 1.40 meters

p. 32—*Measuring by the Metric System*

A. 1. 6″
2. 15 cm. or 150 mm.
3. 25 mm.
4. 2½
5. 3.937 or 4
6. 10
7. 10
8–10. Obvious.
11. Measurements:
   2 3/16 ″ high
   2 3/16 ″ wide
   55.6 mm. high
   55.6 mm. wide
   5.6 dec. high
   5.6 dec. wide

p. 33—*Measuring by the Metric System* (continued)

B. 1, 2, 3. Individual answers.

p. 34—*Measuring by the Metric System* (continued)

C. Individual graphs.

p. 35—*Metric Measurement of Children*

1.

Name	*Birth*	*Height*	*Waist*	*Inside Leg Length*
Heinz	April 4, 1908	71.7″ or 5′11.7″	35.4″	34.6–35.4″
Edith	Aug. 31, 1913	63″ or 5′3″	28.7″	30.3″
Werner	Oct. 22, 1937	53.5″ or 4′5.5″	26.4″	25.2″
Wolfgang	Sept. 29, 1940	51.9″ or 4′3.9″	25.6″	23.2″
Christian	July 17, 1942	46″ or 3′10″	22.8″	19.3″
Regina	Oct. 6, 1946	33.5″ or 2′9.5″	22.8″	12.2″

2–3. Individual answers.

p. 36—*Metric Measurement by Volume*

1. Column 1: Individual answers.

Column 2:

1. 32 oz. (1 qt.)	7. 2 oz.
2. 8 oz. (½ pt.)	8. 3 oz.
3. 16 oz. (1 pt.)	9. .7 oz.
4. 14 oz.	10. 128 oz. (1 gal.)
5. 6 oz.	11. 3½ oz.
6. 6 oz.	12. 2 oz.

Column 3: (The following figures were arrived at by multiplying the number of fluid ounces in each bottle by 29.6, the number of cubic centimeters in a fluid ounce. If desired, any of these figures can be reduced to cubic decimeters or to liters.)

1. 947.2 cc.	7. 59.2 cc.
2. 236.8 cc.	8. 88.8 cc.
3. 473.6 cc.	9. 207.2 cc.
4. 414.4 cc.	10. 3,788.8 cc.
5. 177.6 cc.	11. 103.6 cc.
6. 177.6 cc.	12. 59.2 cc.

2. Individual answers.

p. 37—*What Is the Important Problem?*

A. Circle *my* and *skin.*
B. Circle *me and skin.*
C. Circle 4.
D. *a.* Circle 1, 2, 3, 4, 8.
b. Circle 1, 2, 3, 4, 5, 6, 7, 8, 11, 12.
c. Circle 5, 6, 7, 8, 11, 12.
d. Circle 1, 2, 3, 4.

p. 38—*Skins of Plants and Animals*

Individual drawings.
1–2. Individual answers.

p. 39—*Using Scientific Facts to Explain Myself*

A. 1. *a.* hair follicle
b. epidermis
c. hair
2. *a.* corium
b. piece
c. multiply
3. *a.* sweat gland
b. hollow
c. skin
4. *a.* hair follicles
b. sebaceous
c. surface
5. *a.* sebaceous glands
b. air
c. crusts

p. 40—*Using Scientific Facts to Explain Myself* (continued)

6. *a.* ceruminous
b. cerumen (wax)
c. skin

B. 1. *a.* Draw a circle around the word *cells* in each sentence.
b. cells
2. *a.* Sentences 1(*a*), 2(*a*) and (*c*).
b. cells
3. Circle *multiply.*
4. Cells multiply.
5. Underline *change.*
6. multiply . . change
7. cells multiply and change

p. 41—*Using Scientific Facts to Explain Myself* (continued)

8. *a.* hair   *b.* fingernails   *c.* toenails

C. 1. glands
2. Sentences 3(*a*), 4(*b*), 5(*a*), 6(*b*).
3. glands
4. Circle *make.*
5. glands make
6. Underline *perspiration, oil,* and *wax.*
7. substances
8. substance
9. glands make them
10. Both produce substances or things in the body.
11. Different things are made by them.
12. cells

p. 42—*Using Scientific Facts to Explain Myself* (continued)

13. cells
14. change . . make
15. multiplying . . changing . . making . . glands

The Nervous System and Pain

Individual answers.

p. 43—*The Human Body and Sunlight*

1. Sunlight helps destroy bacteria and fungi on the skin.
   Sunlight helps the body produce Vitamin D.
   Sunlight is essential for healthy, active life.
2. Same as 1.
3. Same as 1.
4. Same as 1.
5. Dirty skin interferes with the production and elimination of wax and perspiration.
6. Each part of the body depends upon all other parts to function properly.

p. 44—*Experiments with Water and Soap*

A. 2. Individual drawings.
4. Individual drawings.

B. 1. The glass in which salt was added.
2. The glasses containing borax and the boiled water.

C. 1. soft
2. Any minerals which would make it hard were left in the teakettle.

p. 45—*Improving One's Personal Appearance*

Individual answers.

Growth of Fingernails

Chart: Individual answers.

p. 46—*How Well Can You State Problems?*

A. 1. How should I clean my skin?
2. How should I clean my hair?
3. How should I remove dandruff?
4. How should I remove wax?
5. How should I remove blackheads?
6. How should I clean and cut my nails?

B. 1. skin
2. hair
3. dandruff
4. wax
5. blackheads
6. nails

C. 1. clean skin
2. clean hair
3. remove dandruff
4. remove wax
5. remove blackheads
6. clean and cut nails

D. 1–6. yes.

p. 47—*Responsibility for Equipment*

1. *a.* knife
b. test tube
c. soap
d. litmus paper
e. distilled water

2–5. Individual answers.

7. *a.* gummed labels
b. paper
c. cake of soap
d. cloth
e. newspaper

p. 48—*Responsibility For Equipment* (continued)

8. *a.* Use soap. *b.* Cut soap.
9. Individual answers.

p. 50—*How to Select Information from Different Kinds of Materials*

1. Fighting a Forest Fire
2. Check: *a*, *b*, *d*, *f*.
3. Check: *a*, *b*.
4. Check: *a*, *b*, *c*, *d*.
5. *a*. from the stream
   b. main road, old trail
   c. fire lines made, flanks confined
   d. out of canyon, up the hill
6. *a*. Direction in which fire was moving.
   b. How fire could be reached.
   c. What was done to fight fire.
   d. Size and shape of fire.

p. 51—*How to Select Information from Different Kinds of Materials* (continued)

7. Individual maps.
   a, *b*, *c*, *d:* Individual answers.

p. 52—*Where Are the National Forests?*

1. 33
2. Individual answers.
3. Check: *a*, *b*, *c*, *d*, *e*. Circle: Individual answers.

p. 53—*Where Are the National Forests?* (continued)

4. Individual answers.

Fire in the Forest

A. 1. weather instruments . . humidity
   2. telephoned
   3. friction . . heat
   4. field glasses . . smoke
   5. sighting bars . . circle . . degrees
   6. degrees
   7. pilot
   8. radio operator

p. 54—*Fire in the Forest* (continued)

9. trucks
10. cooking equipment
11. pumpers
12. wind . . paw
13. dynamiting
14. diesel tractor
15. slope
16. clear . . ground
17. parachute
18. emergencies
19. drift
20. horses
21. temperature . . ignite . . air
22. dew
23. evidence

B.

1.	weather instruments	6.	radio	11.	explosives
2.	telephone	7.	airplanes	12.	diesel tractor
3.	field glasses	8.	trucks	13.	parachute
4.	sighting bar	9.	cooking	14.	rope
5.	map	10.	engine	15.	horses

p. 55—*Protecting Forests*

1. Write FIRE under picture 1, 4, 5.
2. Write SAFE under picture 2, 3, 6.
3. Obvious.

p. 56—*Food and Water in a Plant*

Diagram: Water goes up through the xylem, just inside the bark. Food goes down through the phloem, inside the cambium. Both xylem and phloem are in the sapwood.

The arrows for food point downward because the leaves manufacture food which is carried to all parts of the tree and used or carried to the roots where it is stored.

The arrows for water point upward because the roots absorb water which must be carried to the leaves for them to use in manufacture of food.

p. 57—*Trees*

1. Individual diagrams.
2. Individual answers.
3. Paint acts as a preservative and is more effective above ground where there is less moisture. Below ground, insects, moisture, mold, fungi work to rot the wood. Above ground the air dries the wood and causes it to split and crack.

p. 58—*Water and Plants*

2. Individual drawings.
3. The source of water affects the root growth of plants by causing the roots to grow in the direction of the water.

p. 59—*Light and Plants*

1. Individual drawings.
2. Individual drawings.
3. The amount of light and the direction from which it comes affect the growth of plants. If plants do not receive a sufficient amount of light, they do not grow well. Plants will grow toward the light. Plants grow well in sunlight but not in electric light.

p. 60—*Roots and Leaves of Plants*

A. 1. They are both parts of the plant; they are both in water.
   2. Roots are white, leaves green; shape; size; location.

B. 1. Each is composed of cells.
   2. The leaf has green bodies in it; the root does not.

C. 1. They are both parts of the plant; each is made of cells.
   2. Location, size, shape, green bodies.
   3. Small sections surrounded by walls.
   4. Both made of cells, contain green bodies, and have roots and leaves. One grows on land, one in water.

p. 61—*The Pith of Plants*

Individual drawings.

p. 62—*What Do You Need to Know about Problems?*

A. 1. How do trees grow?
  2. *a.* Underline 10.
    b. Cross out 1, 3, 6, 7.
    c. Circle 2, 4, 8, 9.
    d. Check 2, 4, 8.
    e. Check 2, 4, 8.
  3. *a.* Underline 2.
    b. Cross out 4, 5.
    c. Circle 1, 3, 6, 7, 8.
    d. They are too general.
    e. It is specific.

p. 63—*What Do You Need to Know about Problems?* (continued)

B. 1. *a.* (1) Roots—anchor tree, take food and moisture from soil.
      (2) Trunk—supports crown, passageway for food and moisture.
      (3) Crown—holds leaves in sunlight.
    b. phloem
    c. xylem
    d. heartwood, sapwood
    e. food materials, sunlight, moisture, carbon dioxide, and oxygen.
  2. *a.* chlorophyll
    b. absorption
    c. cell division
    d. cells divide
    e. cells divide
    f. height, shape, circumference

p. 64—*What Do You Need to Know about Problems?* (continued)

B. 3. Group I: roots, crown, trunk, chlorophyll, phloem, xylem, heartwood, sapwood
  Group II: cell division, absorption
  Group III: supporting, anchoring, holding, transporting

Group IV: carbon dioxide, oxygen, minerals, sunlight, moisture

4. Group I: A tree is made of many different parts.
   Group II: Certain processes occur in trees.
   Group III: A tree carries on many functions.
   Group IV: A tree uses many different materials.
5. When the parts of a tree function and use materials, certain processes occur and growth results.

p. 65—*Try It Yourself*

Step I: How is a tree's age determined?

Step II: tree's age

Step III: tree—a tall plant with a woody stem
age —how long it has lived

Step IV: A. What characteristics of a tree help determine its age?
B. What methods are used to determine the age?

Step V: A. 1. annual rings
2. diameter of tree
B. 1. Count annual rings.
2. Measure diameter of tree and estimate by the diameter of a tree on which annual rings have been counted.
3. Use drill to extract plug and count the annual rings.

Step VI: Underline: annual rings; diameter of tree; count; measure; use drill.

Step VII:

Characteristics	*Methods*
annual rings	count
diameter of tree	measure, use drill

p. 66—*Try It Yourself* (continued)

Step VIII: 1. Trees have two characteristics which determine their ages.
2. There are three methods which can be used to determine the age of a tree.

Step IX: Certain characteristics of a tree are examined to determine its age.

Finding the Main Idea in a Paragraph

1. Paragraph 1: M before *a*, E before *b*, *c*, *d*.
   Paragraph 2: M before *b*, E before *a*, *c*, *d*.
   Paragraph 3: M before *d*, E before *a*, *b*, *c*.

p. 67—*Finding the Main Idea in a Paragraph* (continued)

Paragraph 4: M before *b*, E before *a*.
Paragraph 5: M before *c*, E before *a*, *b*.
Paragraph 6: M before *b*, E before *a*.
Paragraph 8: M before *a*, E before *b*, *c*, *d*.
Paragraph 12: M before *a*, E before *b*, *c*, *d*.

p. 68—*Finding the Main Idea in a Paragraph* (continued)

Paragraph 13: M before *b*, E before *a*, *c*, *d*.
Paragraph 14: M before *a*, E before *b*, *c*.
Paragraph 17: M before *a*, E before *b*, *c*, *d*.

2. Circle in sentences marked M:
   Paragraph 1: eating habits affect . . behavior
   Paragraph 2: few people . . have developed eating habits that . . need no improvement
   Paragraph 3: Eating . . process of preparing food for the body to use.
   Paragraph 4: digestion takes place more easily in the stomach if the food . . is in small, soft pieces
   Paragraph 5: Entire sentence.
   Paragraph 6: Entire sentence.
   Paragraph 8: Because of the wide use of . . refrigerators . . families have an abundant supply of ice.
   Paragraph 12: the way you feel when you eat is . . important
   Paragraph 13: Emotions . . different kinds
   Paragraph 14: Emotions . . another effect . . digestive system
   Paragraph 17: Each member of the family . . make each meal a happy, pleasant experience

3. Underline:

Paragraph 1: *b.* unpleasant feelings . . result of your eating
c. pleasant
d. tired . . cross

Paragraph 2: *a.* eat any time
c. fussy about the kind of food
d. eating habits that are desirable

Paragraph 3: *a.* Food is changed physically
b. Food is changed chemically
c. eating habits . . help . . change . . food

Paragraph 4: *a.* chew . . food well . . saliva . . well mixed with food

Paragraph 5: *a.* eaten slowly . . chewed thoroughly . . body . . use
b. food . . poorly chewed . . quickly swallowed . . without being digested

Paragraph 6: *a.* Part of the food . . never be digested

Paragraph 8: *b.* cold food . . drinks
c. ice water . . meal
d. stomach . . functions best . . contents . . warm

Paragraph 12: *b.* Anger retards . . digestive juices
c. not . . eat . . you . . angry
d. Fear . . interferes . . digestion

Paragraph 13: *a.* Perhaps you are just bored
c. Digestion . . slowly . . body cells do not receive . . food
d. excited, afraid, angry, bored, irritable, anxious, worried, or tired . . movements . . muscles . . stomach . . hindered

Paragraph 14: *b.* rice . . mouth . . spit it out
c. gastric juices stop flowing

Paragraph 17: *b.* You . . do your part.
c. enjoy meals one . . like . . many kinds of food.
d. meal . . pleasant experience for others

4. Check *a*, *b*, *c*, *d*, *e*.

p. 69—*A Diary of Your Stomach*

Individual diaries.

p. 70—*I Examine My Eating Habits*

1. Individual chart.
2. Individual answers.

p. 71—*Testing Foods*

A. 3. Individual answers.

p. 72—*Testing Foods* (continued)

C. 1. Individual answers.
   3. Individual charts.

p. 73—*Getting Information from a Table*

1. Circle: *food, % water*
2. Water Content of Certain Foods.
3. food and percentage of water
4. *a.* Circle 1 and 3.
   b. Underline 2 and 4.
5. General questions: 1—yes
   3—87% to 99%
   Specific questions: 2—87%
   4—90% to 99%
6. The percentage of water in food varies.
7. Individual answers.

p. 74—*What Are Reading Signals?*

1. *a.* Digestion.
   b. What are lips for?
   c. How does the tongue help you chew and swallow food?
2. *a.* lips *b.* tongue
3. *a.* digestion
   b. p. 133
   c. How does food get into the pharynx?
   d. food
   e. p. 115
   f. (1) Vitamin D (2) Vitamin G

4. *a.* Kinds of Forest Fires *b.* How Trees Grow
5. *a.* Kinds of forest fires
   (1) Ground fire
   (2) Surface fire
   (3) Crown fire
   (4) Methods of fighting forest fires
   b. How trees grow

p. 75—*What Are Reading Signals?* (continued)

6. *a.* numbers
   b. (1) by numbers (2) 3 (3) three
   c. (1) night (2) blindness (3) epithelial (4) cells
7. Page 140: sub-topic, italicized words
   Page 143: italicized words, four
   Page 147: sub-topic, italicized words
   Page 148: sub-topic, italicized words, numbers, three
   Page 149: sub-topic, italicized words, three
   Page 152: sub-topic, numbers, four
   Page 154: main topic, sub-topic
8. Individual answers.

p. 76—*Starch and Saliva*

A. 3. *a.* The starch grains have been broken up.
   4. The starch grains without the saliva are unchanged. Those with saliva are dissolving.
   5. *a.* It is dissolving.
   6. Saliva digests starch.

B. 1. It turns blue, purple, or black.

p. 77—*Starch and Saliva* (continued)

   2. It turns blue, purple, or black.
   3. It is not so blue, or no reaction if digestion is complete.
   4. Because we wanted to discover if starch was digested by saliva.
   5. That saliva digests starch.

Digestion

Individual diagrams.

p. 78—*Selecting the Main Factor in an Experiment*

II. white cloth reflects more light than dark cloth

III. A. Individual drawings.

B. 1. in the sunlight

2. 5 minutes

IV. Individual answers.

p. 79—*Selecting the Main Factor in an Experiment* (continued)

V. 1. Circle all except *color of cloth.*

2. One has no cloth; one has white cloth; one has black cloth.

3. Color affects temperature.

4. To answer the question: Did the cloth make a difference?

5. Individual answers.

VI. 1. Cloth affects temperature.

2. Color of cloth also affects temperature.

1. There is a control.

2. Only one factor is different.

VII. The color of cloth helps determine the temperature inside the test tube.

VIII. Individual answers.

p. 80—*A Balanced Menu for a Three-Day Hike*

Menu: Individual answers.

p. 81—*Digestion and Food Cooking*

A & B. Individual answers.

p. 82—*Digestion and Food Cooking* (continued)

4. *a.* Uncooked white is liquid; cooked white is solid.

b. It has changed state and color.

5. Individual answers.

6. Yes. Cooking changes substances which must be changed again during digestion.

C. 1–3. Individual answers.

4. No. 2.

5. No. 2. It is more tender and has to be changed less during digestion.

D. 1. Individual answers.

p. 83—*Digestion and Food Cooking* (continued)

D. 4. No. 2

E. 1. *a.* Boil or steam.
b. Soft boil.
c. Cook quickly in hot pan.
d. Cook without water, or steam.

2. *a.* softens
b. hardens
c. changes color, softens
d. softens

3. *a, b, c, d*: easier to digest

4. heat

5. physical. The foods changed color, size, shape, consistency, but remained nearly the same foods if properly cooked.

p. 84—*Foods for Plants*

2. Individual drawings.

3–4. Individual answers.

p. 85—*The Human Body and Its Food*

A. 1. air, soil, water, plants, animals
2. eggs, beef, bananas, carrots, sardines
3. bakery, packing house, sugar factory, canning factory, breakfast food factory
4. railroad, truck, airplane
5. digestion, absorption, assimilation
6. repair, energy, growth
7. seeds, bacteria, cellulose
8. Waste is eliminated.
9. sewage-disposal plants
10. air, soil, water

B-C-D. Individual illustrations.

p. 86—*The Meaning of Words*

1. Done.	
3. Cross out *transparent.*	Write *opaque.*
5. Cross out *convex.*	Write *concave.*
6. Cross out *incandescent.*	Write *fluorescent.*
7. Cross out *compounds.*	Write *elements.*
12. Cross out *positive.*	Write *negative.*
14. Cross out *follicles.*	Write *capillaries.*
15. Cross out *white.*	Write *tactile.*
16. Cross out *solution.*	Write *emulsion.*
17. Cross out *rootlets.*	Write *root hairs.*
18. Cross out *medullary.*	Write *annual.*

p. 87—*The Meaning of Words* (continued)

19. Cross out *carbohydrates.*	Write *fats.*
22. Cross out *Vitamin B.*	Write *Vitamin A.*
23. Cross out *Vitamin C.*	Write *Vitamin B.*
24. Cross out *sublingual.*	Write *parotid.*
27. Cross out *larynx.*	Write *pharynx.*
29. Cross out *insulin.*	Write *pancreatic juice.*
32. Cross out *blood.*	Write *lymph.*
34. Cross out *trypsin.*	Write *insulin.*

p. 88—*Scientific Thinking*

1. Check: *a, c, d, e.*
2. Circle: *j, q, r, s.*
3. Place an X before: *b, k, l, m, n.*

p. 89—*Scientific Thinking* (continued)

4. Each person thought he saw something different.

p. 90—*Compounds and Mixtures*

1. *a.* elements
   b. elements . . compounds
   c. molecule
   d. elements . . compounds . . molecule

2. *a.* mixture
   b. compound
   c. compound
   d. element
   e. element
   f. compound

p. 91—*Gravity and the Atmosphere*

A. 1. The pull of gravity holds atmosphere to the earth.
   2. Gravity causes atmosphere to rotate as the earth rotates.
   3. Gravity prevents molecules of gas from flying off in all directions.
   4. Gravity causes greater pressure to be exerted near the surface of the earth.

p. 92—*Gravity and the Atmosphere* (continued)

B. 1. The pull of gravity holds atmosphere to the earth.
   2. Gravity causes greater pressure to be exerted near sea level.
   3. Gravity prevents molecules of gas and water from flying off in all directions.

p. 93—*The Pressure of the Atmosphere in Your Community*

Individual drawings and answers.

p. 94—*Our Dependence on the Sun*

Check: 1, 2, 4, 5, 7, 8, 9, 10, 11, 13, 14.
Individual answers for reasons for decisions.

p. 95—*Heat and the Earth*

A. Underline 1. waves . . sun
   2. sun . . ultra-violet
   3. ultra-violet . . ultra-violet
   4. infra-red rays
   5. infra-red rays
   6. infra-red rays
   7. infra-red rays
   8. heat waves
   9. heat waves

B. Circle: 1. substances
2. water vapor . . dust . . other substances
3. atmosphere . . atmosphere
4. atmosphere . . surface
5. substances
6. substance
7. rocks . . soil . . oceans . . lakes . . buildings
8. heated objects
9. air . . upper layers . . atmosphere
10. surface . . trophosphere

Above Your Community

Individual drawings in notebooks.

p. 96—*A Problem*

A. Question: How have scientists found out these things about the atmosphere?

1. trophosphere
2. airplanes
3. tops of mountains
4. stratosphere
5. balloons
6. instruments
7. ionosphere
8. meteors
9. light
10. meteorites
11. telescope
12. glow
13. radio waves
14. aurora borealis
15. density
16. observe
17. study
18. discover

B. 1. troposphere . . stratosphere . . ionosphere
2. Circle: 2, 5, 11.
3. Check: 8, 9, 10, 12, 13, 14, 15.
4. Underline: 16, 17.

C. 1. troposphere . . ionosphere . . stratosphere
2. airplane . . balloons . . telescope
3. meteors, light, meteorites, glow, radio waves, aurora borealis, density

p. 97—*A Problem* (continued)

C. 4. observation, study

D. Individual answers.

E. Order of statements: 2, 1, 4, 3.

Another Problem

Individual answers.

p. 98—*Pressure*

1. Bracket: Jan. 15 through Jan. 24—High
   Jan. 25 through Jan. 27—Low
   Jan. 28 through Feb. 1—High
   Feb. 2 through Feb. 6—Low
   Feb. 7 —High
2. Individual answers.

p. 99—*How to Select Specific Facts to Answer a Question*

Place a 1 before: 1, 2, 9.
Place a 2 before: 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16.
Place an E before: None

p. 100—*How to Select Specific Facts to Answer a Question* (continued)

Place a 1 before: None
Place a 2 before: 17, 18, 19.
Place an E before: 20 through 35.
Individual answers.

p. 101—*Care of an Instrument*

a. Color bulb.

b. *Care of a Thermometer*
1. Never handle the bulb.
2. Carry in a holder.
3. Use carefully.
4. Don't use to stir.
5. Keep away from flames.
6. Use only when necessary.
7. Don't put into a rubber stopper unless you know how to do it.

c. *The Storing of a Thermometer*
1. Place in cardboard holder or in a box on cotton.

2. Place in cupboard away from other equipment that might fall on it.

p. 102—*Getting More Information*

Individual charts and answers.

p. 103—*Why Weather Is Predicted*

Individual answers.

p. 104—*Weather Instruments*

1. *a.* thermometer
   b. barograph, barometer
   c. anemometer
   d. wet-dry bulb thermometer, rain gauge, snow tube
   e. photoelectric cell
2. by reading
3. Certain weather conditions are more conducive to fires than others.
4. *a.* Storms affect forest fires.
   b. Dry weather aids forest fires.
   c. Regional conditions affect fires.
   d. Pathways of storms affect fires.
   e. Seasonal characteristics affect fires.

Summarize Your Information

First Column:	Second Column:	Third Column:
1. sunshine	1. photoelectric cell	1. heat
2. wind	2. anemometer	2. speed; direction
3. moisture	3. wet-dry bulb thermometer; rain gauge; snow tube	3. moisture
4. temperature	4. thermometer	4. heat
5. pressure	5. barometer; barograph	5. air pressure

p. 105—*How Scientists Gather Information*

1. *a.* Gather information.
   b. Interpret data.
   c. Use knowledge.
   d. Record findings.
   e. Transmit findings.
   f. Compare with other years.

2. *a.* Useful to aviation, navigation, agriculture.
   b. Knew basic elements to observe.
   c. Gathered knowledge.
   d. Kept records and were trained.
   e. What the weather will be.
   f. Weather can be predicted.
3. *a.* Weather affected them.
   b. They used what they saw or heard.
   c. Superstitions.
   d. They didn't have enough information.

p. 106—*How Scientists Gather Information* (continued)

3. *e.* Superstitions.
4. *a.* Gather information; predict; collect information, to use in the future.
   b. Kind of information gathered; instruments; conclusions; usefulness.
5. *a.* Uses instruments; doesn't jump to conclusions; changes ideas on basis of evidence.
   b. Keep same ideas; jump to conclusions; use only observation.

Scientific Principles and Machines

Page Number	*Name of Machine*	*Use of Machine*
217	electric motor	for labor-saving machines
218	electric sewing machine	sewing
218	electric mixer	cooking
218	vacuum cleaner	cleaning
218	electric fan	cooling
218	movie projector	showing movies
218	washing machine	washing
218	stoker	moving coal

p. 107—*Problem Solving by Experiments*

A. 1. These circles or iron filings show that a wire carrying an electric current is surrounded by a magnetic field.

2. The lines of filings around the wire look very much like the lines of filing around a bar magnet.
3. A bar of steel put in a coil through which current is passing will change the bar so that it will pick up iron filings.
4. When an iron core is in an electro-magnet, it will pick up more tacks.
5. When there are a great number of turns of wire, the electro-magnet will pick up more tacks than when there are fewer turns of wire.
6. When more dry cells are added, more tacks can be picked up.
7. A compass needle indicates that the poles of an electric magnet are reversed when the direction of the current is changed.

p. 108—*Problem Solving by Experiments* (continued)

B. Obvious.

p. 109—*Problem Solving by Reading*

1. *a.* By generators.
   b. A large machine which produces electricity.
   c. It is turned very fast.
   d. Some kind of power must be used (steam or water).
   e. Electricity is produced by machines called generators when they are turned rapidly by steam or water power.
2. Problem: How does a generator work?
   a. A large number of wires are mounted.
   b. A number of electro-magnets are passed by them rapidly.
   c. As magnets pass by wires, fields of force of magnets flow around wires.
   d. Wires wound around slots in iron drum.
   e. Either wires or magnets may move.
   f. Electricity is produced.
   g. Brushes may be needed to carry current from generator if armature moves.

h. A generator consists of coils of wire and electromagnets, either of which may turn, break the fields of force, and produce electricity.

p. 110—*Explore Your Home for Electrical Appliances*

Individual answers and charts.

p. 111—*A Graph*

A. 1. Places Where Electricity Is Used
2. *a.* Number of uses. *b.* Places in which uses occurred.

p. 112—*A Graph* (continued)

B. 1. Circle *a, b, c, d, e, g, i, j.*
2. Check *a, b, d, e, g.*
3. Underline *c, i, j.*
4. *a.* homes, schools, garages, filling stations, stores, factories, hospitals, hotels; *b.* homes; *c.* yes; *d.* schools; *e.* yes; *g.* no; *i.* no; *j.* no
5. *a.* homes, schools, garages, filling stations, stores, factories, hotels, hospitals; *b.* homes; *d.* schools; *e.* yes; *g.* no
6. *c.* yes; *i.* no; *j.* no

p. 113—*A Graph* (continued)

C. 1. Places vary in number of uses of electricity.
Homes have the most uses for electricity.
Schools have the least uses for electricity.
2. Order: 8, 5, 6, 3, 1, 7, 9, 4, 2.
3. Individual graphs.

p. 114—*How Are Some Electrical Devices Alike?*

A. 1. electricity
2. *a.* Electricity is sent out on wires above the street-car tracks, and the street-car motor uses the electricity.
b. When the motor turns, the drum revolves and winds up the cable like thread on a spool.

c. The common street lighting arrangement is made by powerful electric light bulbs placed inside glass bowls which diffuse the light.

d. The different bulbs are on separate circuits, and the wires are led to a peculiar kind of switch.

e. Neon signs are made of tubes from which most of the air has been removed and to which a small quantity of neon gas has been added. A wire is sealed into each end of the tube. High-voltage current is passed through the tube.

3. They all use electricity.
   They use electricity in different ways.

p. 115—*Scientific Knowledge Changes the Way People Live*

1. *a.* pages 232–233
   b. pages 233–234
   c. pages 234–235
   d. page 235

p. 116—*Scientific Knowledge Changes the Way People Live* (continued)

2. Plants and Health:
   Column 1: A spirit of helpfulness which came from religious interests.
   Column 2: Plants grew in monastery gardens where the first hospitals were established.
   Column 3: Gradually knowledge developed about the effects of plants on man.
   Column 4: Some plants help to cure people who are ill.
   Column 5: Plants can be used to cure some diseases. A knowledge of the right plants is essential.

p. 117—*Scientific Knowledge Changes the Way People Live* (Continued)

3. Public Health:
   Column 1: Need to remove refuse and provide drainage.
   Column 2: Inconvenient not to provide drainage and remove refuse.

Column 3: Less disease, better health, more pleasant environment.
Column 4: There is a relationship between clean water, no refuse, proper drainage, and health.
Column 5: Public health can be controlled by controlling refuse, drinking water, and drainage.

p. 118—*Scientific Knowledge Changes the Way People Live* (continued)

4. Communicable Diseases:
   Column 1: Reduce number of deaths from epidemics and prevent epidemics.
   Column 2: Many thousands of people died after each epidemic.
   Column 3: Fewer diseases, fewer epidemics.
   Column 4: People could transfer disease.
   Column 5: Disease can be transferred by people, and people must be isolated when they have contagious diseases.

p. 119—*Scientific Knowledge Changes the Way People Live* (continued)

5. Diseases on Shipboard:
   Column 1: To cure and prevent illness of sailors.
   Column 2: Sailors were ill without obvious cause.
   Column 3: Sailors were cured and disease prevented.
   Column 4: Lemon juice is necessary in diet of sailors to prevent disease.
   Column 5: There is a relationship between diet and disease. Certain diseases are caused by deficiencies in vitamins.

p. 120—*Information from Pictures*

1. people, activity, clothing
2. Old Time Medicine
3. What is done today for a sick man on the street.
4. Circle *c*. Check *a*, *b*, *d*, *e*.

5. People employed magic and tried to make the patients comfortable.
6. *a.* old-fashioned
   b. hold handkerchief, hold sticks, call witch doctor
   d. filthy
   f. friends, witch doctors
7. *a.* Magic was used to cure sick people
   b. People were frightened.
   c. People knew illness could be transferred.
8. Individual drawings in notebook.

p. 121—*Arranging Ideas in a Logical Order*

1. *a.* Reproductive parts of plant develop.
   b. Pollination occurs.
   c. Fertilization occurs.
   d. Seeds develop.

2. I. How do begonias reproduce?
   - A. Reproductive parts develop.
   - B. Pollen transferred from male to female flowers.
   - C. Fertilization occurs in ovary.
   - D. Seeds develop in ovary.

3. I. How do begonia plants reproduce?
   - A. Reproductive parts develop.
     1. The male flower develops pollen and stamens.
     2. The female flower develops pistil with ovary.
     3. The plant produces male and female flowers.

p. 122—*Arranging Ideas in a Logical Order* (continued)

   - B. Pollen is transferred.
     1. Pollen is carried from anther to pistil.
     2. Pollen grain divides and grows.
     3. Sperm cell reaches ovule.
   - C. Fertilization occurs.
     1. One sperm will enter an egg.
     2. One egg will admit one sperm.
     3. Egg and one sperm unite.

D. Seeds develop in ovary.
   1. Fertilized egg grows.
   2. Seed is formed.
   3. Peduncle withers.

4. I. How are perfect flowers different from other flowers?
   A. Perfect flowers have both male and female parts in same flower.
      1. Each flower has stamens and pistils.
      2. Hollyhocks, cherry, and pear have both stamens and pistils.
   B. Perfect flowers are pollinated.
      1. Insects pollinate them.
      2. They are self-pollinated.

p. 123—*Plants and Fruits*

Individual labels. In each case the seed and the developed ovule are the same.

1. Part of the flower in which the ovules develop.
2. Part of the flower in which the egg develops.
3. The matured fertilized ovule.

p. 124—*Making a Fire Extinguisher*

1. When the vinegar mixes with the soda and water, carbon dioxide is formed which foams out.
2. Individual drawings.
   The test tube keeps the vinegar from mixing with the soda and water as long as both bottle and tube are upright.
   When tube and bottle are inverted, the two liquids mix and form carbon dioxide which keeps the air containing oxygen away from the fire.
3. The carbon dioxide which is formed is heavier than air and keeps the air containing oxygen away from the fire. Without air the fire cannot burn.

p. 125—*Fuel and Temperature*

1–2. Individual answers.

p. 126—*Applying Facts to Pictures*

1. Obvious.
2. *a.* carbon *b.* oxygen

p. 127—*Application of a Scientific Fact*

1. *a.* wood
   b. coal
   c. gas
   d. kerosene
   e. gasoline
   f. electricity
   g. none
   h. none
2. *a.* All can be used to cook food.
   b. All depend on fuel to operate.
   c. All depend on union of oxygen and carbon for heat.
3. In the fuels used and in construction.

Getting Information from a Diagram

1. How a Fireplace Works
2. *a.* wood
   b. fireplace
3. *a.* results of burning wood
   b. fireplace construction

p. 128—*Getting Information from a Diagram*

4. Check *a, b, c, g.*
5. *a.* on andiron
   b. like a quarter of a circle with hole at top
   c. above and in front of fuel
   g. curved back of fireplace
6. Fuel burns and produces heat, part of which is directed into the room.
7. Individual diagrams.

p. 129—*The Effect of Temperature*

1. *a.* The one who stood the jar upside down in the warm water.
   b. Heat was applied to the metal top.
   c. It caused the metal top to expand.
2. Individual answers.

3. *a.* It does not change.
   b. It expands.
   c. Heat was applied.
   d. They expand.

p. 130—*The Effect of Temperature* (continued)

4. Individual answers.
5. They expand.

Contraction and Expansion

1. Color: obvious.
   When heat in oven rises above temperature set, copper tube expands and partially closes valves in burners.
   When temperature of room goes above temperature set, the strips expand, bend, touch one of points. Electric current then flows and shuts draft in furnace.

p. 131—*Contraction and Expansion* (continued)

2. *a.* A house has both warm and cold gases in it. Warm air from a furnace expands and moves into room where it warms the cooler air. The warm air is pushed up from the floor by the cold air, and spreads out over the room. As it cools and contracts, it settles to the floor to be reheated.
   b. (1) fireplace (2) piped furnace (3) pipeless furnace
   c. See pages 285–287 of How and Why Explorations.
3. As water is heated in flask, the lighter, warmer water is forced up through the tube by the cold water. As it reaches the top of the coiled tube, it gradually cools and comes down the straight tube.

p. 132—*Application of the Knowledge of Fuels*

Individual answers.

p. 133—*The Effect of Temperature on Different Thermometers*

Individual answers.

The Effect of Heat and Cold on the Temperature Recorded for the Human Body

1. Usually 94° F. to 106° F.

2–5. Individual answers.

p. 134—*Effects of Unequal Pressure*

1. *Page 256:* Unequal pressure causes cold air to enter furnace and warm air to go out of furnace.
   Page 257: (same as above)
   Page 261: Unequal pressure causes fresh air to enter mine and stale air to go out of mine.
   Page 262: Air is pushed to surface by pressure of gas on its surface.
   Page 265: Less gas in tubes makes it possible for accumulation of warm gas to move through them.
   Page 284: Cold air coming into teepee forces warm air to outside.
2. Individual answers.

p. 135—*Movements of the Jaw*

A. 1. lower
   2. up and down, sideways

B. 1. Circle extreme upper right of illustration.
   2. joint
   3. The upper jaw is part of solid portion of skull and is not jointed.

p. 136—*Structure and Function of the Teeth*

1. Molars: 8; flat and broad; crush, grind; provide large surface for crushing and grinding
   Bicuspids: 8; flat and broad; crush, grind; provide large surface for crushing and grinding
   Canines: 4; narrow and pointed; tear; provide sharp surface for cutting and tearing
   Incisors: 8; narrow and pointed; tear and cut; provide sharp surface for cutting and tearing

Wisdom: 4; flat and broad; no special function

2–3. Individual answers.

p. 137—*Tooth Decay*

1. Underline: the words *diet, carbohydrates, bread, sugar, potatoes, macaroni, acid* each time they appear.

   Circle: *bacteria* each time it appears.
2. diet—all foods one eats
   bacteria—small, one-celled plants
   carbohydrates—the starches and sugars one eats
   acid—a sour substance which turns blue litmus red
   bread—a carbohydrate
   sugar—a carbohydrate
   potatoes—a carbohydrate
   macaroni—a carbohydrate
3. *a.* Use litmus paper to test the acidity of the solution.

p. 138—*Tooth Decay* (continued)

b. Individual answers.

c. Individual answers.

4. Individual answers.

p. 139—*Why My Teeth Decay*

1. Worms get in teeth. —Bacteria, not worms, get into the teeth.
2. Worms eat on the inside of teeth. —The action of bacteria causes teeth to decay.
3. When they eat away to a nerve, I sure know they are there. —Other things press on the exposed nerves in decayed teeth and cause them to ache, but not worms.

Another Cause of Tooth Decay

1. Fluorine is an element. Carbohydrates are compounds.
2. Underline: fluorine, mineral, acid.
   Circle: people, scientists, bacteria.
3. heredity

p. 140—*Kinds of Engines*

1. Pressure is produced by heating steam. Expanding gas moves the piston.
2. Expanding gases move the piston.
3. Electricity from a power station is transferred to engine.
4. As the steam expands, it exerts a strong pressure between the stationary blades of the drum on the rotor blades. The blades move; the rotor turns.

A Spark Gap

1. *a.* There is a hole in it.
   b. A spark.
   c. Heat is produced; the paper may burn.
   d. In the spark gap enough heat can be produced to ignite the fuel and air mixture.

p. 141—*A Spark Gap* (continued)

   e. Individual drawings.
2. So that the widest possible gap is made across which the spark will jump.

Scientific Facts and Transportation

1. Facts about Electricity.
   a. An iron core makes an electro-magnet stronger.
   b. The greater the number of turns of wire, the stronger the electro-magnet.
   c. The strength of an electro-magnet is increased when the current is stronger.
   d. The poles of an electro-magnet are reversed by changing direction of the current through the coil.

   Facts about Fuels.
   a. Carbon combines with oxygen.
   b. When carbon and oxygen combine, heat is produced.
   c. When carbon and hydrogen unite with oxygen, producing heat, burning takes place.
   d. A fuel must be heated to its kindling point before it will burst into flame.

p. 142—*Scientific Facts and Transportation* (continued)

2. The temperature of water can be raised sufficiently to change the water from a liquid state to a gaseous state.	Combustion will take place in cylinders when air is compressed so that its heat will vaporize and ignite fuel.
The force of expanding gases can be used to move wheels.	The force of expanding gases can be used to move wheels.
The shape of objects determines the amount of air resistance trains encounter.	Electricity can be conducted by wires to the place where it is needed.
Air resistance reduces speed of moving trains.	Electric current can be varied to vary speed of train.

p. 143—*What Is the Effect of Expanding Gases?*

1. *a.* It comes out of the test tube.
   b. Individual diagrams. When the test tube was heated, the air in the test tube became warm, expanded, and forced the cork from the test tube.
2. Individual drawings.
   Step No. 3—The rapid expansion of the gases produced by the burning fuel exerts a powerful force on the piston which drives it downward again in the cylinder.
3. They are similar in that the force is the same—expanding gases. They are different in the following respects—source of fuel, use made of the force.

p. 144—*A Summary*

The pressure of any gas increases as it is heated.
Electricity can be generated.
Compressed gases exert pressure.
Air pressure can be decreased by streamlining.
Liquids may be changed to gases.
Vaporized fuels can be ignited.
Electricity can be conducted over wires.

A Vocabulary Exercise

A.
1. side rod
2. cab
3. throttle
4. piston
5. valve
6. steam
7. boiler
8. compression
9. fuel
10. cylinder
11. water trough
12. stoker
13. fire door
14. rails
15. clapper
16. axle
17. piston rod
18. fire tubes
19. bell
20. drivers

p. 145—*A Vocabulary Exercise* (continued)

B.
1. crosshead
2. throttle
3. exhaust
4. forced draft
5. flange
6. tender
7. automatic coupler
8. streamlining
9. internal-combustion engine
10. stroke
11. turbine-driven locomotive
12. steam turbine

p. 146—*A Vocabulary Exercise* (continued)

Obvious.

p. 147—*Pure Water*

1–3. Individual drawings.

p. 148—*Pure Water* (continued)

4, 5. Individual drawings.

6. *a.* Water is essential to the life of each community. The original source of water for each community is precipitation.

b. The amount of water available in each community. What happens to the water between precipitation and evaporation in each community. The immediate source of some of the water. The amount that is stored for each community.

p. 149—*Scientific Facts About a Community*

Farm Community: It has brown loam soil; an average annual precipitation of 10–14 inches; an average annual temperature range of 50; and a growing season of 160 days (average annual).

Trailer Camp: It has an average annual temperature range of 30; an average annual growing season of 110 days; an average annual precipitation of under 10 inches; and sandy soil.

Quonset Community: It has an average annual temperature range of 30; sandy soil; an average annual precipitation of 10–14 inches; and an average annual growing season of 60 days.

Residential Community: It has an average annual precipitation of 20–29 inches; stony soil; an average annual temperature range of 45; and an average annual growing season of 110 days.

p. 150—*Volcanoes*

Volcanoes occur in mountainous regions.

Volcanoes occur on islands as well as continents.

More volcanoes occur near oceans or shorelines rather than in interiors of continents.

There are no important volcanoes in Australia or Greenland.

The outer regions are free of volcanoes.

Most of the volcanic regions run north and south.

p. 151—*The Importance of Minerals*

Individual answers.

p. 152–155—*Identifying Rocks*

Key: for answers to pp. 152–155, see key on p. 155.

Bottom of page 155—1. shale 2. sandstone

p. 156—*The Geological History of a Community*

1. The river was a means of transportation and a good place for a community. Roads were built across the valley in which the city was located. Because the river was there, bridges had to be built. The oil well was possible because of the formation of oil pockets in the rock. A railroad was built across the plains to follow the curve of the mountain, etc.

p. 157—*The Geological History* [illegible] ed)

2. Water flowing down the mountain eroded land and made a lake in whose bottom animal skeletons were embedded. The water formed a deeper and deeper river bed which cut through the layers of rock and exposed them. Finally the layer in which the skeletons were embedded was exposed.

p. 158—*Exploring an Ancient City*

Individual answers.

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